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Resin bees of genus *Megachile*, subgenera *Callomegachile* and *Carinula* (Hymenoptera, Megachilidae) from Thailand with description of a new species

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Abstract

Resin bees of the genus *Megachile* subgenus *Callomegachile* sensu lato (Hymenoptera; Megachilidae) from Thailand are reviewed. The 14 species treated include those described or revised in the subgenus *Alocanthedon*, a junior synonym of *Callomegachile* (three species), and in *Carinula* (one species). One new species is described, *Megachile chiangmaiensis* Chatthanabun and Warrit, **sp. nov.** The replacement name *Megachile parornata* Chatthanabun, Warrit and Ascher, **nom. nov.**, is proposed for *M. gigas* Wu (not Schrottky), which is recorded for the first time outside China. For each species, maps and full label data for the examined material documenting occurrences in Thailand are provided. In addition, global ranges, floral associations, and other life history data are summarized and a key to the Thai species is provided for females.

Keywords

Apoidea, Megachilini, Pollinator, Southeast Asia

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Introduction

Bees in the subgenus *Callomegachile* Michener, 1962, of the genus *Megachile* Latreille, 1802 (both sensu lato of Michener 2007) are resin and mud-collecting megachilines native to the Old World that vary from moderate in size to gigantic for a bee (9.0–40.0 mm) and have an elongate, parallel-sided "chalicodomiform" body shape. *Callomegachile* are widespread in the Old World where native to the Paleotropics including all of sub-Saharan Africa, most of Asia extending northwards to subtropical and temperate latitudes, and the Australian region. At least 115 described species of *Callomegachile* sensu lato are currently known (Ascher and Pickering 2020; including 8 species of subgenus *Carinula* Michener, McGinley & Danforth, 1994) making it the most species-rich subgenera of resin bees and the second most species-rich overall (after the leafcutter bees subgenus *Eutricharaea* Thomson, 1872) in the genus *Megachile* (the third most species rich bee genus with 1490 valid species globally; Ascher and Pickering 2020), Most *Callomegachile* species collect plant resins as material for nest construction, hence the common name resin bees. In common with other species of Michener's (2007) *Megachile* Group 2, species of *Callomegachile* do not fold regularly-cut leaves to make their nests (a synapomorphy of his Group 1, corresponding to genus *Megachile* sensu stricto (Litman et al. 2011; Trunz et al. 2016; Gonzalez et al. 2019)), but some can incorporate irregularly-cut leaf pieces into nests, especially for making closures (Michener 2007).

In the New World, *Megachile* (*Callomegachile*) *umbripennis* Smith, 1853 is adventive on several Pacific Islands including the Hawaiian Islands and also locally in the Western Hemisphere (Michener 2007; Gonzalez and Engel 2012) where recently detected in South Florida (Ascher et al. 2016). *Megachile* (*Callomegachile*) *sculpturalis* Smith, 1853 of East Asia is now adventive in Eastern North America and widely distributed, having been found in southern Canada and in all of the Eastern United States (and in the Central States as far west as Nebraska, Kansas, and Texas). In addition, *Megachile* (*Callomegachile*) *rufipennis* (Fabricius, 1793) and *M.* (*Carinula*) *torrida* Smith, 1853 are adventive in the West Indies.

As with the delimitation of *Megachile* sensu lato, there has been considerable variation in subgeneric classification of *Callomegachile*, with Michener (2000, 2007) proposing a very inclusive concept of the group while noting the distinctiveness of several named lineages. However, other authors have partitioned these bees more narrowly, with Engel and Gonzalez (2011) describing a new subgenus *Alocanthedon* Engel & Gonzalez, 2011 based in part on clypeal shape in females and the presence of dense patch of black setae on male forewing. However, a recent molecular phylogenetic analysis (Trunz et al. 2016) treated *Alocanthedon* as a junior synonym of *Callomegachile*, which we follow here, pending more thorough investigation of relationships between the African and Asian taxa and, in particular, of the status of the gigantic *Megachile* such as *M. pluto* Smith, 1860 for which the name *Eumegachilana* Michener, 1965 is available (see Michener 2007).

In an analysis that resolved the traditional subgenus *Callomegachile* sensu lato (sensu Michener 2007) as polyphyletic, Trunz et al. (2016) found that *Carinula*, in-

cluding the well-known Asian species *M. stulta* Bingham, 1897, were well separated from typical *Callomegachile*. For sake of completeness, we treat in this work all Thai resin bees including both *M.* (*Carinula*) and *M.* (*Callomegachile*) in the narrower sense, but with the former recognized as a separate subgenus in light of its divergent placement in Trunz et al.'s (2016) phylogenetic trees. It has distinctive characters such as a complete longitudinal median clypeal carina in females and lack of a front coxal spine in males (Michener 2007).

Morphological characters uniting *Callomegachile* sensu Michener (2007) include striate arrangement of punctures on mesoscutum and lower part of mesepisternum; mandibles of female bees usually equipped with 3 to 7 teeth with ridges that are minutely roughened (less so in *Carinula*, as noted by Michener 2007); small appressed hairs present on inner mandibular surface of adductor interspace. In males, the sixth metasomal tergum (T6) is weakly bilobed or lacks median emargination, and the gonoforcep is slender (broadened in *Carinula*) (Michener 1962, 1965, 2007).

Although many *Callomegachile* species are relatively well known and easy to recognize as such, more taxonomic and phylogenetic work is needed to clarify both subgeneric and species limits and to document newly discovered species. Many species described historically have poor original descriptions, are highly variable morphologically (especially in hair color), and have been inaccurately or controversially classified. In addition, the *Callomegachile* sensu lato fauna of Southeast Asia, including Thailand, remains poorly documented, in spite of their abundance and general distribution across the region (Gonzalez and Engel 2012; Ascher et al. 2016). Furthermore, interpretation of their biogeography has been complicated by their propensity to become adventive both across oceans and, potentially, within Asia itself (see Ascher et al. 2016; Soh et al. 2016).

Here, we summarize the occurrence of *Callomegachile* sensu lato species in Thailand from (1) literature records (2) historical specimens in two of the largest insect collection facilities in Thailand (3) the National University of Singapore, Division of Biological Sciences, Insect Diversity Lab database and (4) specimens recently collected from numerous collecting trips from 2006–2019. Distributions records, maps of Thai distributions, floral records, measurements, and images of pinned vouchers are provided based on study of both historical and recently collected specimens. Image records available for six species on the citizen science portal iNaturalist were also reviewed. One *Callomegachile* species new to science is described along with two new records for Thailand, and a replacement name is proposed for a species described from China and newly detected in Thailand.

Materials and methods

Within Thailand, 304 *Callomegachile* specimens (169♀, 135♂) were examined, which were deposited at the Natural History Museum of Chulalongkorn University (**NHM-CU-BSRU**; 147♀, 130♂), Bangkok, the Department of Entomology and Plant Pathology, Faculty of Agriculture, Chiang Mai University (**CMU**; 5♀), Chiang Mai, the Department of National Parks, Wildlife and Plant Conservation (**DNP**; 4♀), Bang-

kok, the Kasetsart Kamphaeng Saen Insect Collection (**KKIC**; 13♀, 5♂), Nakhon Pathom, Thailand. Additional specimens were examined in the Insect Diversity Lab Collection of the National University of Singapore including material on loan from the Oberösterreichisches Landesmuseum of Linz, Austria (curator Fritz Gusenleitner, including material assembled by Maximilian Schwarz). Type repositories used for comparison with specimens examined in this study are abbreviated as follows:

IZB	Chinese Academy of Science, Yunnan, China
MFNB	Museum für Naturkunde, Berlin, Gemany
NHMUK	The Natural History Museum, London, United Kingdom
NMNH	National Museum of Natural History, Smithsonian's Institution Washington DC, USA
USA–SEMC	Snow Entomological Museum Collection, Lawrence
ZMUC	Zoological Museum of the University of Copenhagen, Copenhagen, Denmark

Types of the valid species-group taxa were examined to the extent possible, including those of some but not at all of the names in synonymy. Image records on the citizen science portal iNaturalist were reviewed and identified by JSA.

Specimens were examined and measured with a Zeiss Stemi 508 dissecting microscope equipped with an ocular micrometer or calipers. Body length was measured from edge of clypeus (in dorsal view) to apex of T6. Forewing length was measured from tegula to lateral wing margin. Interocellar distance (ID) and ocelloccipital distance (OD) were measured and these distances were calculated into ID/OD proportion. Male genitalia were dissected following a method modified from Gonzalez (2008). Photomicrographs were prepared using a Canon 7D Mark II digital camera attached to a T2-T2 1.6× SLR long-distance microscope lens, and were processed with Adobe Photoshop CS6. Measurements are reported in millimeters using Axiovision LE 4.8.2.0. Bees were placed in an insect relaxing jar for 3–4 days to soften the specimens for facilitating the examination of mandibles and labrums. Mandibular teeth are numbered sequentially starting from apex toward the base of the mandible. Morphological terminology follows that of Michener and Fraser (1978), Engel (2001), and Michener (2007).

Specimens from NHMCU-BSRU were collected during 1956–1971 (33♀, 4♂) mostly by Dr. Kloom Vajropala of NHMCU-BSRU and 2006–2019 (112♀, 126♂) from recent surveys by the Thai authors. Label data including localities were recorded verbatim for each specimen and, following georeferencing if necessary, were used to construct distribution maps using Adobe Illustrator. Coordinates for the maps were generated based on specimen labels or, for records lacking GPS data, by georeferencing localities using Google Earth and GPS Geoplaner online. To obtain data on global distribution by country and primary subdivisions, literature records were critically reviewed from Tadauchi and Tasen (2009), Ascher et al. (2016), and the Discover Life Bee Species Guide and World Checklist (Ascher and Pickering 2020), and new records obtained were validated for future inclusion in the latter source. Type localities and

repositories are cited, with details provided for those species described from Thailand including new records.

Taxonomy

Genus *Megachile* Latreille

Megachile Latreille, 1802: 413, 433. Type species: *Apis centuncularis* Linnaeus, 1758, by designation of Curtis, 1828, pl. 218.

Subgenus *Callomegachile* Michener

Chalicodoma (*Callomegachile*) Michener, 1962: 21. Type species: *Chalicodoma mystaceana* Michener, 1962, by original designation.
Chalicodoma (*Eumegachilana*) Michener, 1965: 191. Type species: *Megachile clotho* Smith, 1861, by original designation.
Chalicodoma (*Morphella*) Pasteels, 1965: 537. Type species: *Megachile biseta* Vachal, 1903, by original designation.
Chalicodoma (*Orientocressoniella*) Gupta, 1993: 165. Type species: *Megachile relata* Smith, 1879, by original designation [but Gupta's description refers to a bee quite different from the nominal type species, see Baker and Engel 2006].
Chalicodoma (*Alocanthedon*) Engel & Gonzalez, 2011: 53. Type species: *Chalicodoma odontophorum* Engel, 2011, by original designation.

Diagnosis. Body elongate. Female mandible three to seven teeth with minutely roughened ridge. Punctures on mesoscutum and lower part of mesepisternum striated. Small appressed hairs on inner mandibular surface of adductor interspace present. In males, carina on T6 bilobed or lacks median emargination; posterior margin of T6 simple and without tooth.

Comments. The subgenus *Pseudomegachile* Friese, 1898 is superficially similar to *Callomegachile*, in term of size and appearance. Females of *Pseudomegachile* can be recognized by the presence of long erected hairs on inner mandibular surface of adductor interspace, whereas males can be easily recognized by the presence of multidentate apical margin of T6.

Megachile (*Callomegachile*) *atratiformis* Meade-Waldo, 1914

Figs 1, 2

Megachile atratiformis Meade-Waldo, 1914: 456; Female syntype (NHMUK, examined) Mergui (Low Tenasserim), Myanmar.

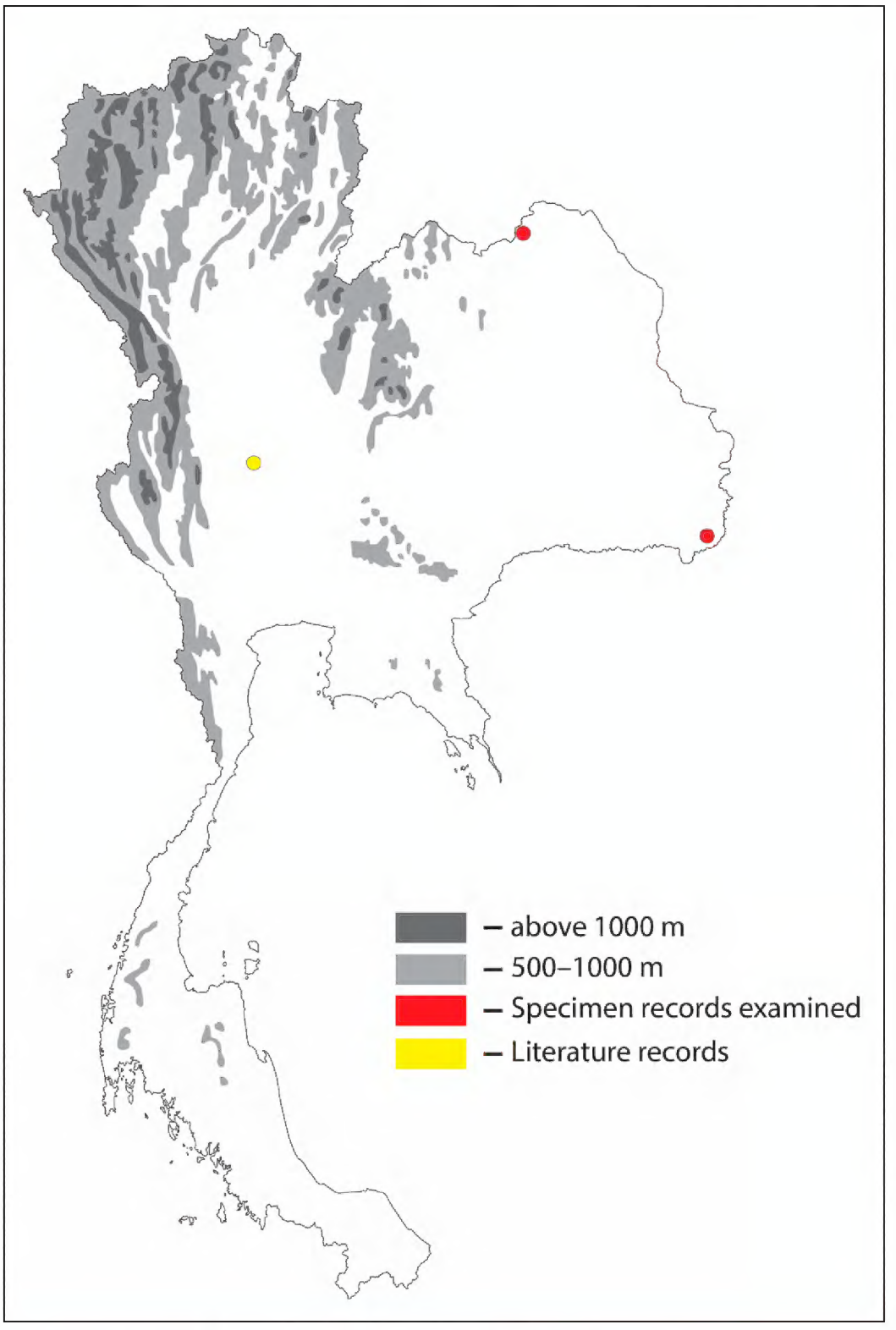


Figure 1. Thai distribution of *Megachile* (*Callomegachile*) *atratiformis*.

Chalicodoma (*Alocanthedon*) *atratiforme* Engel & Gonzalez, 2011: 68–70.

Diagnosis. Female can be easily recognized by its large body size (18–22 mm); black body covered with black hairs throughout (Fig. 2a); clypeus without median tubercle; mandibles four teeth; apical margin of labrum truncate without tooth (Fig. 2d); mesoscutum with weak transverse wrinkle pattern on disc, posteriorly also with weakly transverse wrinkle pattern (Fig. 2e); yellow wings; black scopa. Male can be easily recognized by the presence of black setae patch on medial cell of forewings; apical of T6 with shallow concavity; front tibia modified (Engel and Gonzalez 2011).

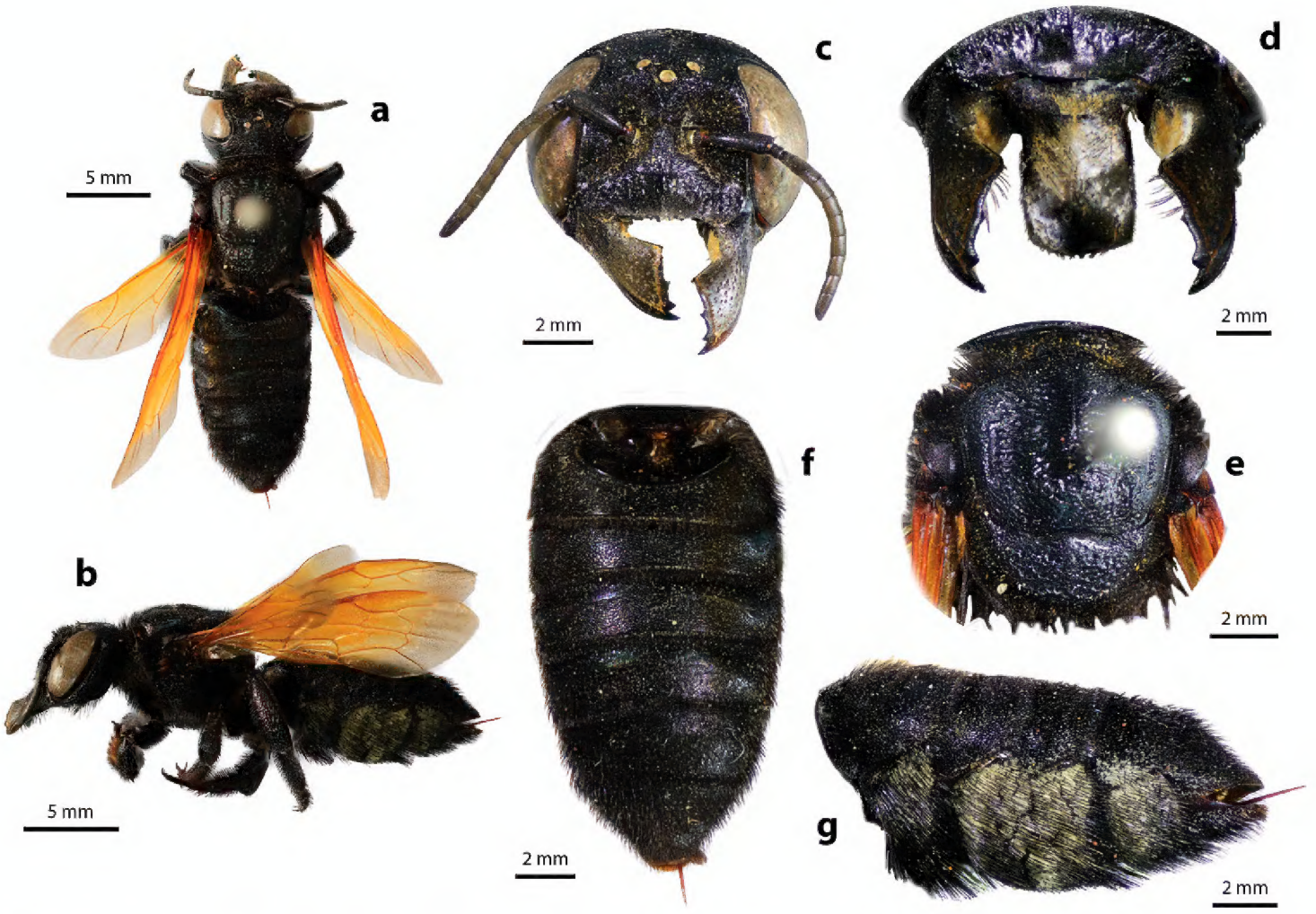


Figure 2. *Megachile* (*Callomegachile*) *atratiformis* Meade-Waldo, 1914, female **a** dorsal view **b** lateral view **c** frontal view **d** frontal view of mandible and labrum **e** dorsal view of mesoscutum **f** dorsal view of metasoma **g** lateral view of metasoma and scopa.

Literature records. Malaysia. Negeri Sembilan, Pahang (Meade-Waldo 1914; Gonzalez and Engel 2011; Ascher and Pickering 2020); Myanmar. Mergui Archipelago in Tanintharyi Region (Meade-Waldo 1914; Gonzalez and Engel 2011; Ascher and Pickering 2020); Thailand. Uthai Thani (Engel and Gonzalez 2011).

Material examined. Female syntype. Myanmar: Tanintharyi Region. "Type H. T.; B.M. TYPE HYM. 2037. 17. a.; *Megachile atrata* (Var), Smith, female; Lower Tenasserim. Mergui, 11–89. C. T. Bingham.; Col. C. T. Bingham 96–30; *Megachile* (*Eumegachile*) *atratiformis* M.W., G. Meade-Waldo det., Type, female; NHMUK 013379843"; Thailand. Nong Khai Province: 1♀, Phon Phisai district, Cowboy Coffee, 18°6'9.95"N, 103°6'17.96"E, Alt. 147.65 m, 15-I-2017, coll. N. Warrit et al. (leg. NC and NW). Ubon Ratchathani Province: 1♀, Phu Jong Na Yoi Nat. P., Kaeng Ka Lao, 14°26'10.98"N, 105°16'37.05"E, Alt. 322 m, 5-I-2019, coll. N. Warrit et al (leg. NC and NW).

Floral records. Engel and Gonzalez (2011) noted the species was captured on an indigenous tree, *Dipterocarpus obtusifolius* Teijsman & Miquel.

Comments. Meade-Waldo's original material was composite (Engel and Gonzalez 2011) so we exclude from the distribution records from Middle Tenasserim: Haundraw [also known as Houngdarau] Valley in Myanmar (= *M. odontophorum*) and also from Penang in Malaysia.

Megachile (*Callomegachile*) *disjuncta* (Fabricius, 1781)

Figs 3–5

Apis disjuncta Fabricius, 1781: 481. Female type (ZMUC, not examined) "America" [erroneous; surely from Asia, and perhaps from India].
Anthophora disjuncta: Fabricius, 1804: 374.
Trachusa disjuncta: Jurine, 1807: 251.
Megachile disjuncta: Lepeletier, 1841: 331.
Megachile (*Pseudomegachile*) *disjuncta*: Friese, 1911: 207.
Chalicodoma (*Callomegachile*) *disjuncta*: Michener, 1965: 191.

Diagnosis. Female can be recognized by its medium body size (13–18 mm); black body covered with black hairs throughout, except propodeal triangle and T1 with white hairs (Fig. 4a); apical margin of clypeus with two small tubercles (Fig. 4d); mandibles five teeth with two stout apical teeth at apex and three small teeth basally; labrum rectangle; apical margin of clypeus truncate with two lateral teeth (Fig. 4e); wings hyaline except fuscous apical part; black scopa (orange in part in females of the superficially similar leafcutter bee *M.* (*Aethomegachile*) *conjuncta* Smith, 1853 which also has a shorter and less parallel-sided metasoma, finer tergal punctures, and cutting edges on mandibles). Male is similar to female except paraocular area and apical margin of clypeus with white hairs (Fig. 5c); mandibles three teeth; labrum rectangle with round corners (Fig. 5d).

Literature records. China. Anhui, Beijing, Fujian, Guangxi Zhuang, Guizhou, Hainan, Hebei, Hunan, Jiangsu, Jiangxi, Shandong, Shanghai, Shanxi, Sichuan, Zhejiang; India. Andaman and Nicobar Islands: Long Island (notable records from Cockerell 1912), Andhra Pradesh, Chandigarh, Haryana, Karnataka, Maharashtra, Puducherry, Tamil Nadu, Uttarakhand (Lepeletier 1841; Smith 1873; Gribodo 1884; Bingham 1897; Cameron 1907; Friese 1911; Cockerell 1912; Cockerell 1919; Flectcher 1920; Dover 1921; Schulthess-Rechberg 1935; Ascher et al. 2016); Indonesia. Java, Sumatra (Gribodo 1884; Schulthess-Rechberg 1935; Ascher et al. 2016); Madagascar. Antananarivo, Bourbon, Toamasina (Gribodo 1884; Grandidier 1890; Pauly 2001; Ascher et al. 2016); Malaysia. Kelantan, Kepong, Kuala Lumpur, Negeri Sembilan, Penang, Selangor, (Ascher et al. 2016); Mauritius. Rodrigues Island (Smith 1873; Gribodo 1884; Bingham 1897; Cameron 1907; Pauly 2001; Ascher et al. 2016); Myanmar. Tenasserim (Bingham 1897; Flectcher 1920; Dover 1921; Schulthess-Rechberg 1935); Reunion. (Pauly 2001; Ascher et al. 2016); Seychelles. Mahe, Morne Blanc, Praslin Island (Cameron 1907; Cockerell 1912; Pauly 2001; Ascher et al. 2016); Singapore. (Ascher et al. 2016); Sri Lanka. Hambantota, Puttalam (Ascher et al. 2016); Vietnam. Thai Binh (Ascher and Pickering 2020). Additional records based on images on iNaturalist are from Bangkok, Chaiyaphum, Surat Thani, and Udon Thani Provinces (credit: lennyworthington 2017; nopcoeur 2018; bernhard_hiller 2019; tonykris 2019; alexeyreshchikov 2020).

Material examined. Thailand. Ayutthaya Province: 1♀, XI-1961, coll. unknown (leg. NC and NW); 1♀, Beung Pra ram, 01-VIII-1970, coll. unknown (leg. NC and

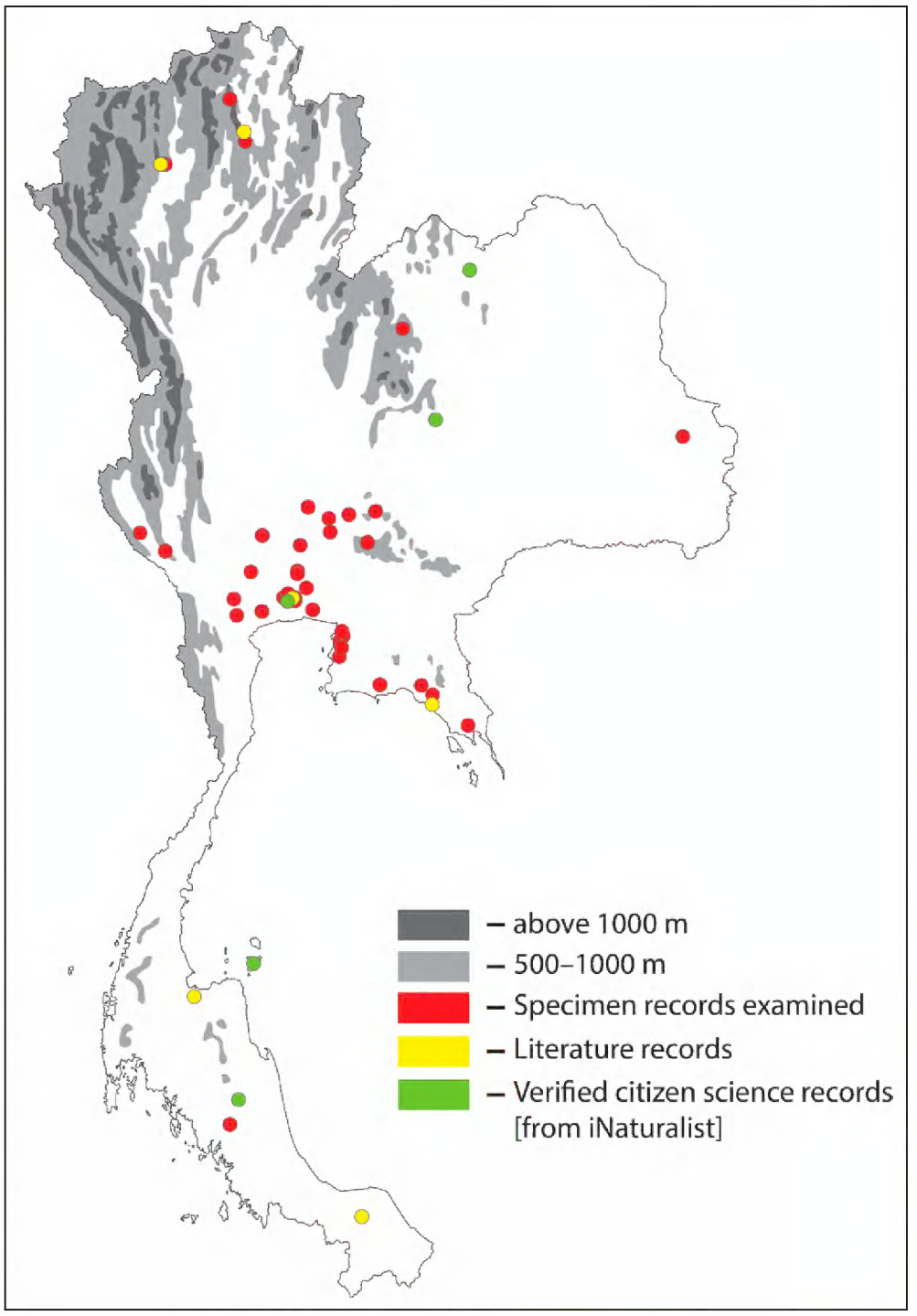

– above 1000 m
– 500–1000 m
– Specimen records examined
– Literature records
– Verified citizen science records [from iNaturalist]

Figure 3. Thai distribution of *Megachile* (*Callomegachile*) *disjuncta*.

NW). Bangkok Province: 1♀, Phra Nakhon, 05-I-1960, coll. unknown (leg. NC and NW); 1♀, Phra Nakhon, 12-VII-1960, coll. unknown (leg. NC and NW); 1♀, 15-II-1963, coll. unknown (leg. NC and NW); 1♀, Nong Khaem district, 16-IX-1966, coll. Wanida (leg. NC and NW); 1♀, Bang Khen district, 19-VII-1969, coll. unknown (leg. NC and NW); 1♀, Thonburi district, 01-VII-1970, coll. unknown (leg. NC and NW); 1♀, Sa Torn district, Thungmahamek subdistrict, 22-IV-1971, coll. unknown (leg. NC and NW); 1♀, 05-VIII-1971, coll. unknown (leg. NC and NW); 1♀, Sathorn district, Soi Suanglu1, 05-X-2009, coll. K. Attasopa (leg. NC and NW); 1♀, Sathorn district, Soi Suanglu1, 06-X-2009, coll. K. Attasopa (leg. NC and NW). Chanthaburi Province: 1♀, Tha Mai district, 19-IX-1969, coll. unknown (leg. NC and NW); 1♀, Makam district, 25-III-2015, coll. N. Chatthanabun (leg. NC); 1♀, 08-V-1956, coll. unknown (leg. NC and NW); 1♀, Bang Pra district, 08-

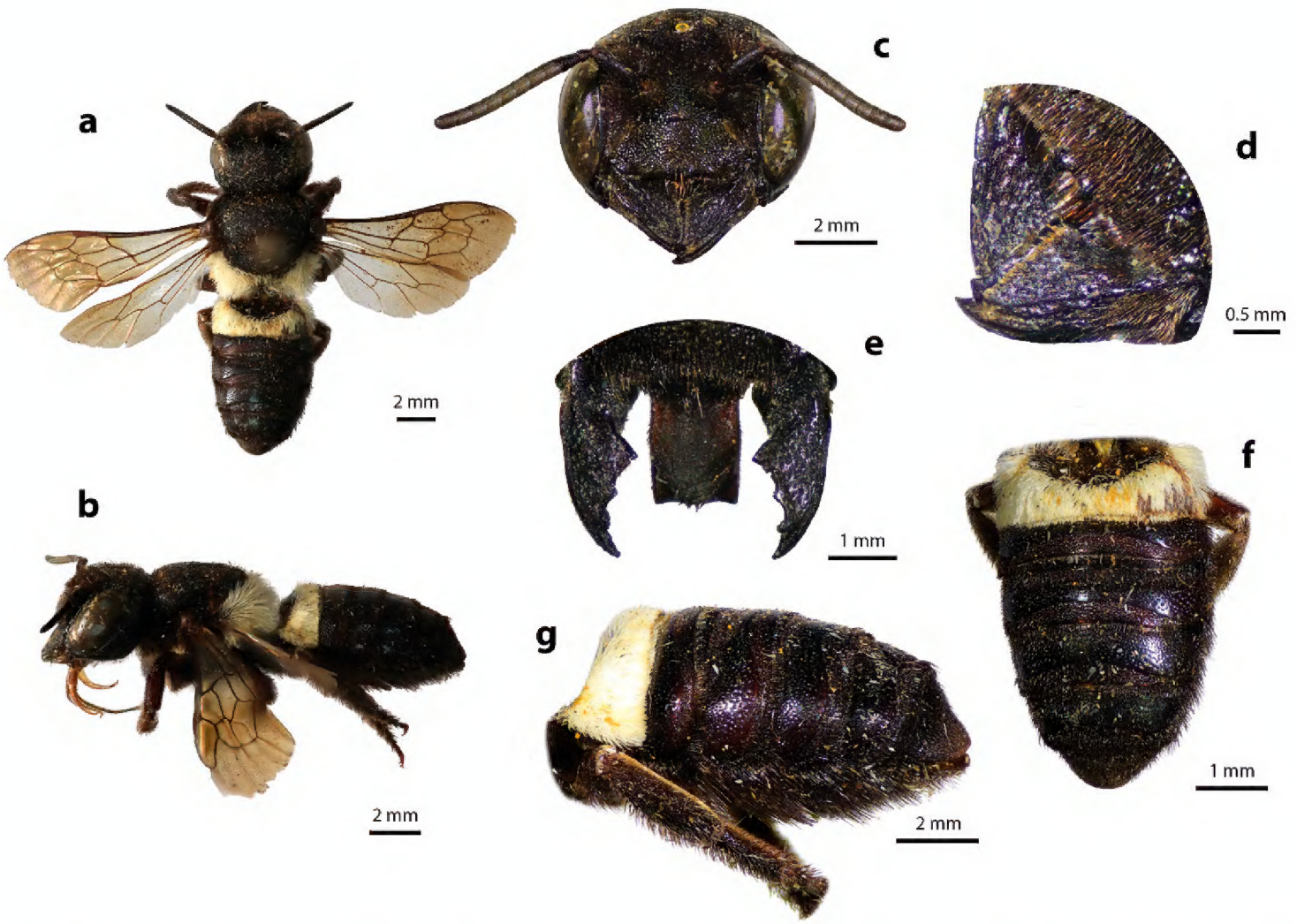


Figure 4. *Megachile* (*Callomegachile*) *disjuncta* (Fabricius, 1781), female **a** dorsal view **b** lateral view **c** frontal view **d** oblique view of clypeal margin **e** frontal view of mandible and labrum **f** dorsal view of metasoma **g** lateral view of metasoma and scopa.

X-1963, coll. unknown (leg. NC and NW); 1♀, Ang Sila, 04-VII-1970, coll. Nonglak (leg. NC and NW); 1♀, Sriracha district, Bang Pra Reservoir, 04-VII-1971, coll. unknown (leg. NC and NW); 1♀, Mueang district, Soi Na Khao Bor Yang, 13°6'10.2066"N, 100°57'59.5764"E, Alt. 15.86 m, 27-VII-2017, coll. P. Traiyasut (leg. NC and NW). Chiang Mai Province: 1♀, 09-VII-1959, coll. Unknown (leg. NC and NW); 39 ♀, Mueang district, Suthep subdistrict, Faculty of Agriculture Chiang Mai University, 18°47'38.6772"N, 98°57'32.9220"E, Alt. 391 m, 19-VII-2015, coll. Warrit et al. (leg. NC and NW); 17♂, Mueang district, Mae Hia subdistrict, 18°45'51.1272"N, 98°55'39.6192"E, Alt. 232 m, 19-VII-2015, coll. Warrit et al. (leg. NC and NW). Chiang Rai Province: 1♀, Pan district, 17-I-2009, coll. T. Yusing (leg. NC and NW). Loei Province: 1♀, Phu Kradueng district, Phu Kradueng National Park, 16°52'22.4934"N, 101°50'11.7384"E, Alt. 506.28 m, 29-V-2016, coll. Warrit et al. (leg. NC and NW). Kanchanaburi Province: 12♂, Sai Yok district, Wang Krachae subdistrict, 14°9'56.7678"N, 99°3'30.5640"E, Alt. 101.80 m, 24-VI-2016, coll. Warrit et al. (leg. NC and NW); 2♂, Sai Yok district, Wang Krachae subdistrict, 14°11'6.5724"N, 99°3'6.9258"E, Alt. 102.30 m, 24-VI-2016, coll. Warrit et al. (leg. NC and NW). Lop Buri Province: 1♀, 10-IX-2013, coll. Warrit (leg. NC and NW). Nakhon Nayok Province: 1♀, Khao Yai National Park, 06-IX-1970, coll. unknown

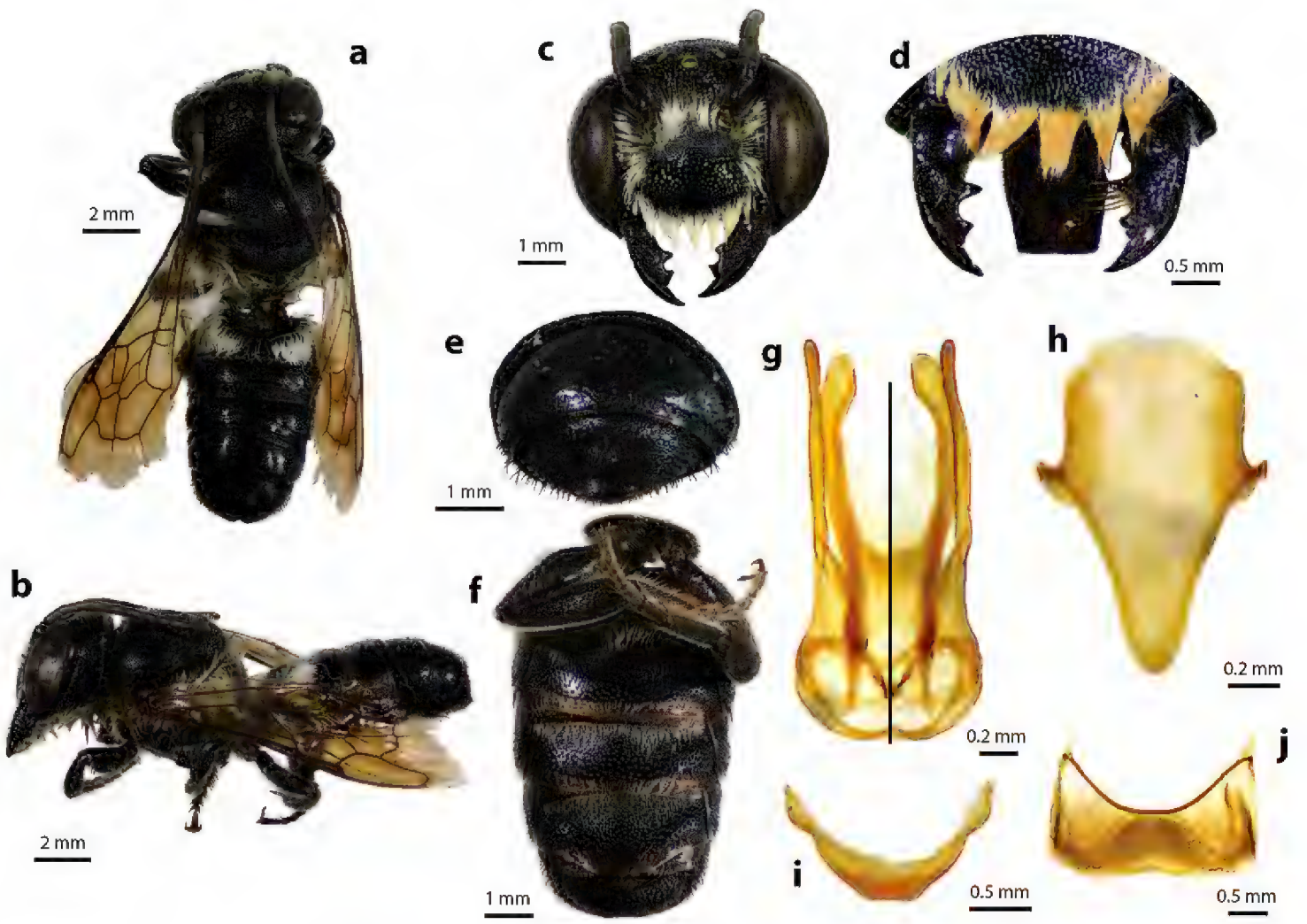


Figure 5. *Megachile* (*Callomegachile*) *disjuncta* (Fabricius, 1781), male **a** dorsal view **b** lateral view **c** frontal view **d** frontal view of mandible and labrum **e** frontal view of T7 **f** ventral view of metasomal sterna **g** dorsal (left) and ventral (right) views of penis **h** dorsal view of S8 **i** T7 **j** S5.

(leg. NC and NW). Nakhon Pathom Province: 1♂, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 06-II-2008, coll. Patneti (leg. NC and NW); 1♂, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 15-VI-2011, coll. Patneti (leg. NC and NW); 1♀, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 30-XI-2013, coll. Sunita (leg. NC and NW); 1♀, 4♂, Kamphaeng Saen district, 13°44'58.3908"N, 99°52'33.1242"E, Alt. 14 m, 10-VII-2015, coll. Warrit et al. (leg. NC and NW); 1♀, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 26-I-2016, coll. Noppasiri (leg. NC and NW); 1♀, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 20-III-2016, coll. K. Laesen (leg. NC and NW); 1♀, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 29-III-2016, coll. Jirawat (leg. NC and NW); 1♀, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 14-IV-2016, coll. Adisak (leg. NC and NW); 1♂, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 11-V-2016, coll. Vilunda (leg. NC and NW); 1♂, Kamphaeng Saen district, Kasetsart University Kamphaeng Saen campus, 04-IX-2016, coll. S. Laengsaruk (leg. NC and NW); 5♀, Kamphaeng Saen district, 14°0'35.1072"N, 100°0'35.9028"E, Alt. 11 m, 12-II-2017, coll. N. Chatthanabun, N. Warrit and V. Sivayyapram (leg. NC and NW). Nakhon Ratchasima Province:

1♀, Pak Chong, 06-I-1964, coll. unknown (leg. NC and NW); 1♀, Pak Chong, 28-VII-1969, coll. W. Sooksri (leg. NC and NW). Nonthaburi Province: 1♀, Pak Kred district, Khlong Phapha, coll. unknown (leg. NC and NW). Pathum Thani Province: 1♂, Ban Ngew district, Samkok subdistrict, Pai rom temple, 18-II-1968, coll. Chairoj (leg. NC and NW); 1♂, 18-II-1968, coll. Rojnee (leg. NC and NW). Phayao Province: 1♂, Mueang district, Mae Ka subdistrict, Phayao University, 03-I-2009, coll. Saowalak (leg. NC and NW); 16♂, Mueang district, Mae Ka subdistrict, Phayao University, 01-VI-2012, coll. Warrit et al. (leg. NW); 1♀, Mae Ka, Phayao University, 19°2'45.3510"N, 99°52'40.5438"E, Alt. 464.26 m, 5-VII-2016, coll. Warrit et al. (leg. NC and NW). Ratchaburi Province: 1♀, 22-VIII-1970, coll. unknown (leg. NC and NW); 1♀, 17-VIII-1973, coll. Pinpong (leg. NC and NW); 2♀, Potharam district, 13°44'50.0070"N, 99°53'38.4180"E, Alt. 6 m, 13-VII-2015, coll. Warrit et al. (leg. NC and NW); 1♀, 01-V-2017, coll. Pornchanok (leg. NC and NW). Rayong Province: 1♀, Ban Pae, 03-VIII-1971, coll. unknown (leg. NC and NW). Samut Prakan Province: 1♂, Park Nam district, 11-VIII-1963, coll. P. Sakulmon (leg. NC and NW). Samut Sakhon Province: 1♂, Banpaew district, 19-VIII-2014, coll. P. Tangtorwongsakul (leg. NC and NW). Saraburi Province: 1♀, 30-VIII-1960, coll. B. Pasook (leg. NC and NW); 1♀, Muak Lek, 03-VIII-1967, coll. unknown (leg. NC and NW); 1♀, Phu Khae, 04-II-1968, coll. Decha (leg. NC and NW); 1♀, Muak Lek, 03-VIII-1971, coll. Unknown (leg. NC and NW). Suphan Buri Province: 1♀, 13-IV-2015, coll. Kaewkan (leg. NC and NW). Trat Province: 1♀, Mueang district, Ao Yai, 23-III-2015, coll. N. Chatthanabun (leg. NC). Trang Province: 1♂, Na Yong district, 7°33'8.0892"N, 99°46'33.6072"E, Alt. 24 m, 11-VI-2015, coll. Warrit et al. (leg. NC and NW). Ubon Ratchathani Province: 1♂, Trakan Phuetphon district, Sarin lake view village, 03-VIII-2014, coll. N. Chatthanabun (leg. NC). Unknown localities: 1♂, 16-VIII-1960, coll. unknown (leg. NC and NW); 1♀, 01-I-1965, coll. unknown (leg. NC and NW); 2♀, 2♂, coll. unknown (leg. NC and NW).

Floral records. Throughout Thailand, *M.* (*Callomegachile*) *disjuncta* can be found abundantly in many agricultural plots that are planted with *Crotalaria juncea* L., a common plant species grown for providing essential nitrogen element to many crop plants in Thailand. Also, a common weed, *Bidens pilosa* L., is frequently visited by the species. One record of *M.* (*Callomegachile*) *disjuncta* was found on *Cratoxylum cochinchinense* (Lour.) Blume.

Comments. Female somewhat superficially resembles *M.* (*Aethomegachile*) *conjuncta* in size and overall appearance.

Megachile (*Callomegachile*) *faceta* Bingham, 1897

Figs 6–8

Megachile faceta Bingham, 1897: 486. Female syntype (NHMUK, examined) Pegu Hills, Myanmar.

Megachile faceta rufojugata: Cockerell, 1931: 2.

Chalicodoma (*Callomegachile*) *faceta*: Michener, 1965: 191.

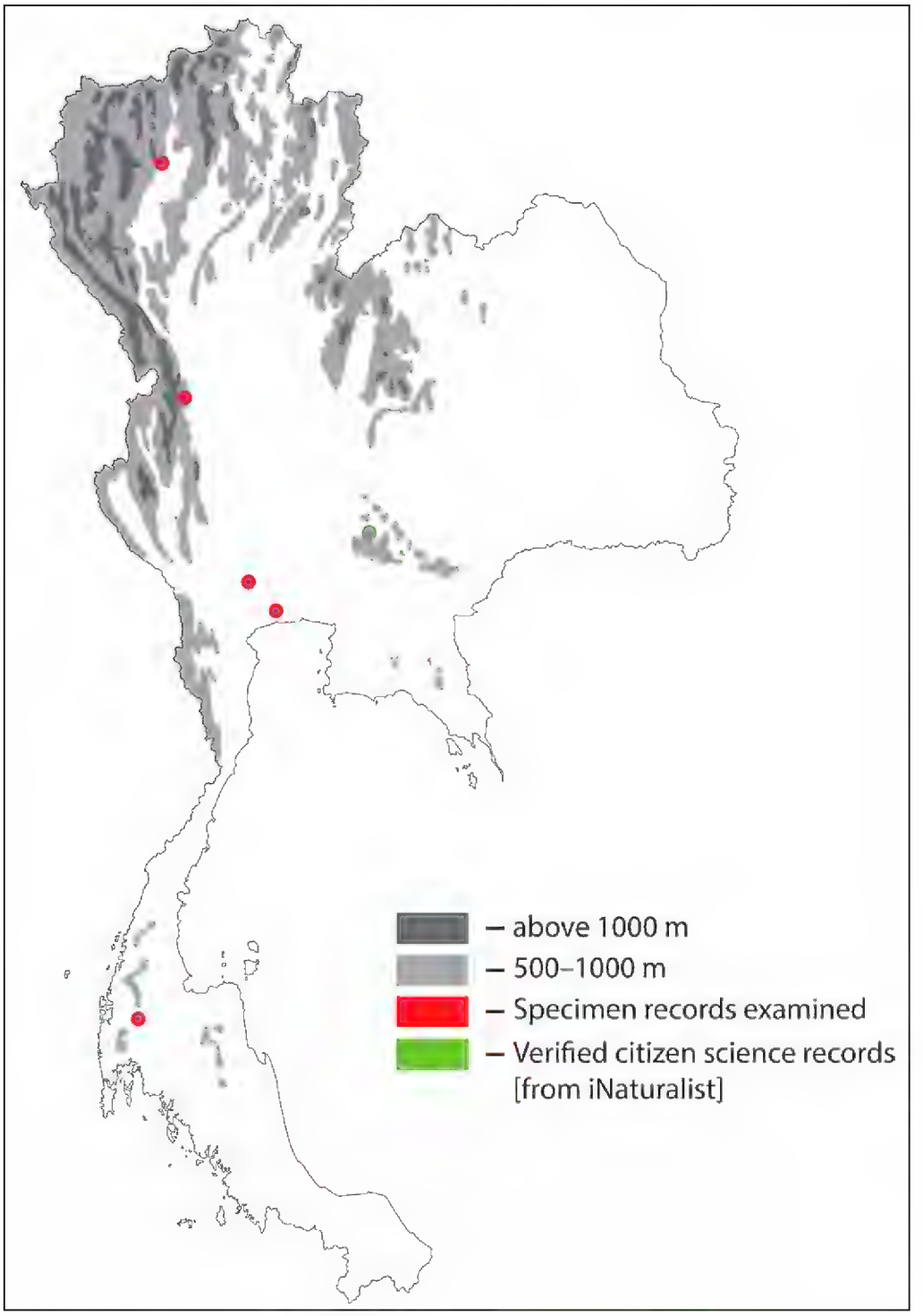


Figure 6. Thai distribution of *Megachile* (*Callomegachile*) *faceta*.

Diagnosis. Female can be recognized by its black medium body size (12–14 mm); vertex and pronotum covered with fulvous hairs; propodeal triangle and T1–T4 with tuft white hairs on lateral edges; apical margin of T5 with white hair band but interrupted at median (Fig. 7a); apical margin of clypeus with two small tubercles (Fig. 7c); mandibles five teeth with two stout apical teeth at apex and three small teeth basally; labrum rectangle with rounded corners (Fig. 7d); vertex with median carina (Fig. 7e); white scopa except black at apical area. Male is similar to female except mandible three teeth; labrum rectangular with shallow impression at median (Fig. 8d).

Literature records. India. Khasia Hills (Cockerell 1911); Myanmar. Pegu Hills [as Bago Yoma], Tanintharyi Region [as Tenasserim] (Bingham 1897); Taiwan. Sauter (Cockerell 1911). An iNaturalist image shows four females among a group of bees photographed at Hin Tung, Mueang District, Nakhon Nayok Province (credit: scottyastro 2015).

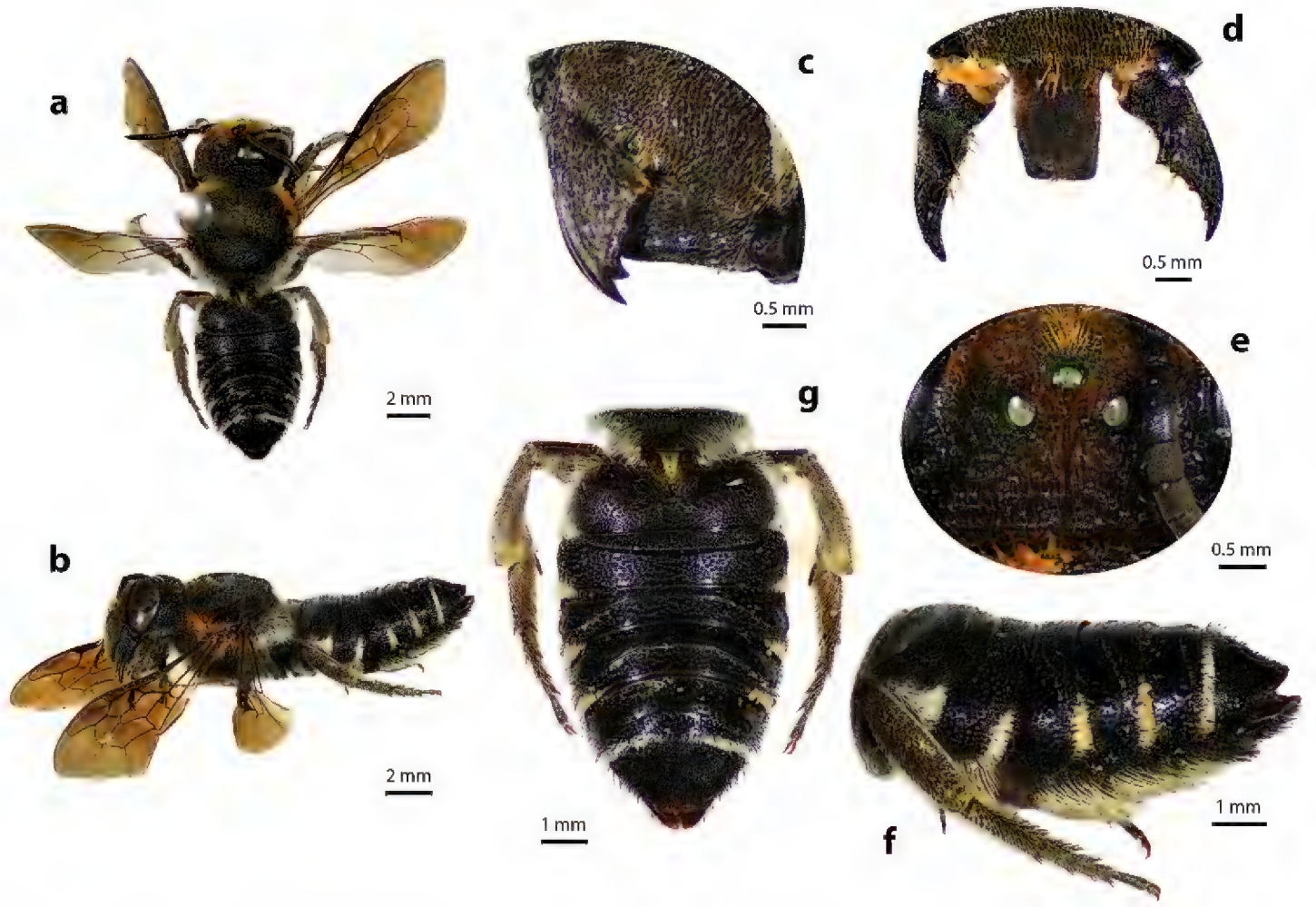


Figure 7. *Megachile* (*Callomegachile*) *faceta* Bingham, 1897, female **a** dorsal view **b** lateral view **c** oblique view of clypeal margin **d** frontal view of mandible and labrum **e** dorsal view of median carina at vertex **f** lateral view of metasoma and scopa **g** dorsal view of metasoma.

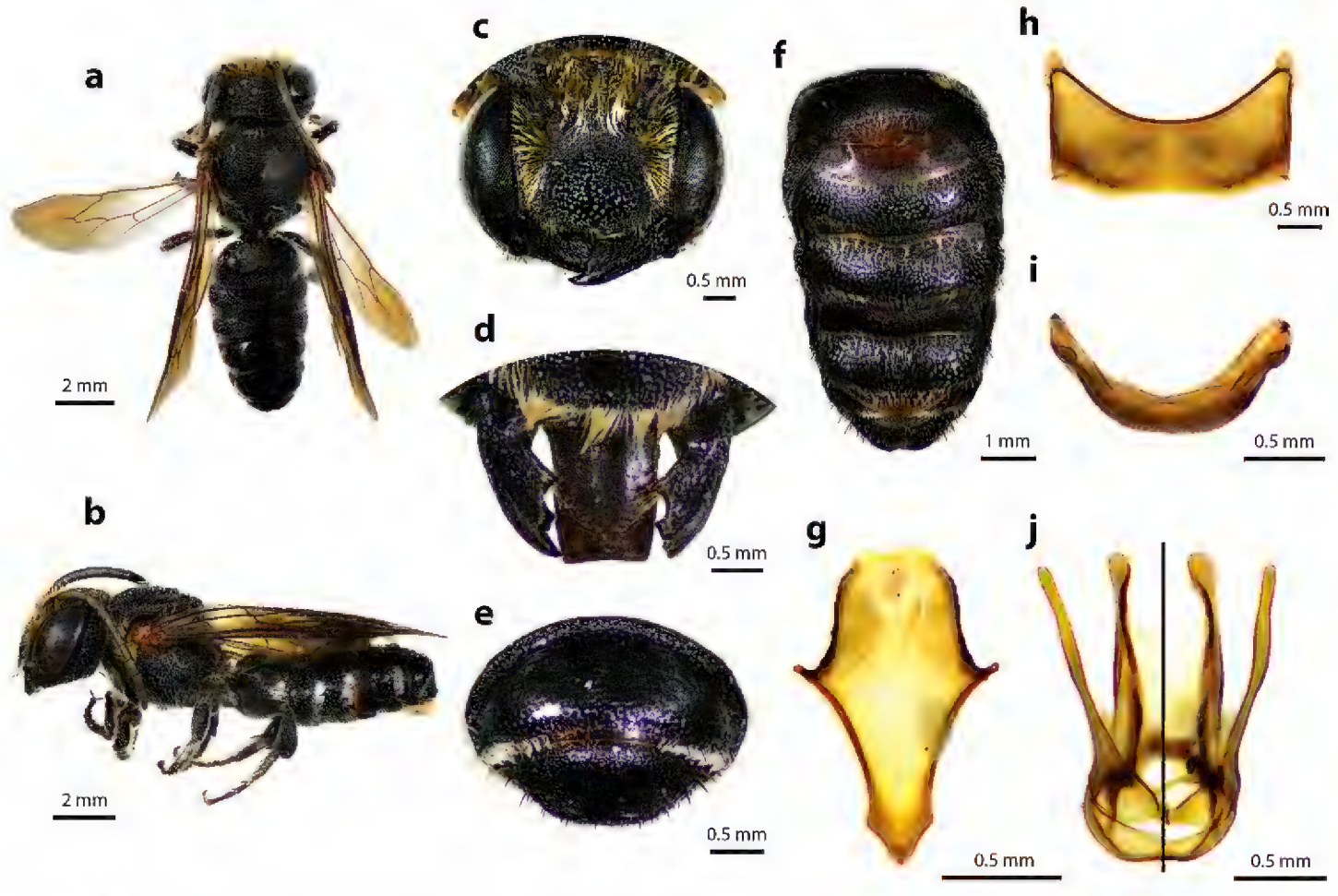


Figure 8. *Megachile* (*Callomegachile*) *faceta* Bingham, 1897, male **a** dorsal view **b** lateral view **c** frontal view **d** dorsal view of mandible and labrum **e** frontal view of T7 **f** ventral view of metasomal sterna **g** dorsal view of S8 **h** S5 **i** T7 **j** dorsal (left) and ventral (right) views of penis.

Material examined. Female syntype. Myanmar. "Type; B.M. TYPE HYM. 2011 17. a.; *Megachile faceta* Bingh. Female, Type; Pegu Hills, Burma, 11-87, Bingham Coll; Col. C. T. Bingham 96–30; NHMUK 013379842"; Thailand. Bangkok Province: 1♀, Pom Prap Sattru Phai district, Khlong Mahanak subdistrict, Sapan Kaw, 18-VII-1971, coll. Sudthida (leg. NC and NW). Chiang Mai Province: 13♂, Mueang district, Mae Hia subdistrict, Mae Hia Agricultural Research, Demonstrative and Training Center, 18°45'51.1272"N, 98°55'39.6192"E, Alt. 232 m, 19-VII-2015, coll. Warrit et al. (leg. NC and NW). Nakhon Pathom Province: 1♀, Kamphaeng Saen district, Kamphaeng Saen subdistrict, Kasetsart University, Kamphaeng Saen Campus, 02-IX-2010, coll. Pakkawat (leg. NC and NW). Nakhon Sawan Province: 2♀, Mae Wong Natural Park, 28-VI-2015, coll. V. Sivayyapram (leg. NC and NW). Surat Thani Province: 1♀, Phanom district, 8°54'35.9460"N, 98°31'37.9590"E, Alt. 118.68 m, 27-I-2018, coll. Warrit et al. (leg. NC and NW).

Comments. The similar *Megachile* (*Callomegachile*) *facetula* Cockerell, 1918, described from Sandakan, Sabah, Borneo, should be looked for in Thailand, but we have not been able to confirm any records. *Megachile strupigera* Cockerell, 1922, from Canton (now Guangzhou in Guandong) in southern China is likely a junior synonym of *M. faceta* based on our examination of images of its type in the NMNH, whereas Wu (2006) placed it in the leafcutter subgenus *Amegachile* Friese, 1909. Multiple species of leafcutter bees present in the region including Thailand closely resembles *M. facetula* in color pattern, so all identifications must be considered structural characters as well.

Megachile (*Callomegachile*) *fulvipennis* Smith, 1879

Figs 9, 10

Megachile fulvipennis Smith, 1879: 68. Female holotype (NHMUK, examined) Nicobar Island, India.
Megachile atratiformis sininsulae Cockerell, 1927: 160.
Chalicodoma (*Callomegachile*) *atratiforme sininsulae*: Michener, 1965: 191.
Chalicodoma (*Callomegachile*) *fulvipennis*: Michener, 1965: 191.

Diagnosis. Female superficially resembles *M.* (*Callomegachile*) *atratiformis* (Meade-Waldo, 1914), *M.* (*Callomegachile*) *memecylonae* (Engel, 2011) and *M.* (*Callomegachile*) *odontophora* (Engel, 2011), in overall appearance: black body covered with black hairs throughout; yellow wings; black scopa (Fig. 10a, f) except smaller size (14–16 mm); punctures on mesoscutum and lower part of mesepisternum striated; mandibles five teeth with two stout apical teeth at apex and three small teeth basally; labrum rectangular (Fig. 10c).

Literature records. India. Andaman and Nicobar Island (Smith 1879; Ascher et al. 2016); Indonesia. Java, Sumatra (Ascher et al. 2016); Malaysia. Perak, Selangor, Terengganu (Ascher and Pickering 2020); Singapore. (Ascher et al. 2016).

Material examined. Female holotype. Nicobar Island [India]. "Holotype; B.M. TYPE HYM. 2055 17. a.; *Megachile fulvipennis* Sm. (Type); Nicobar, 76–30; NHMUK 013379844"; Thailand. Nakhon Pathom Province: 1♀, Kamphaeng Saen

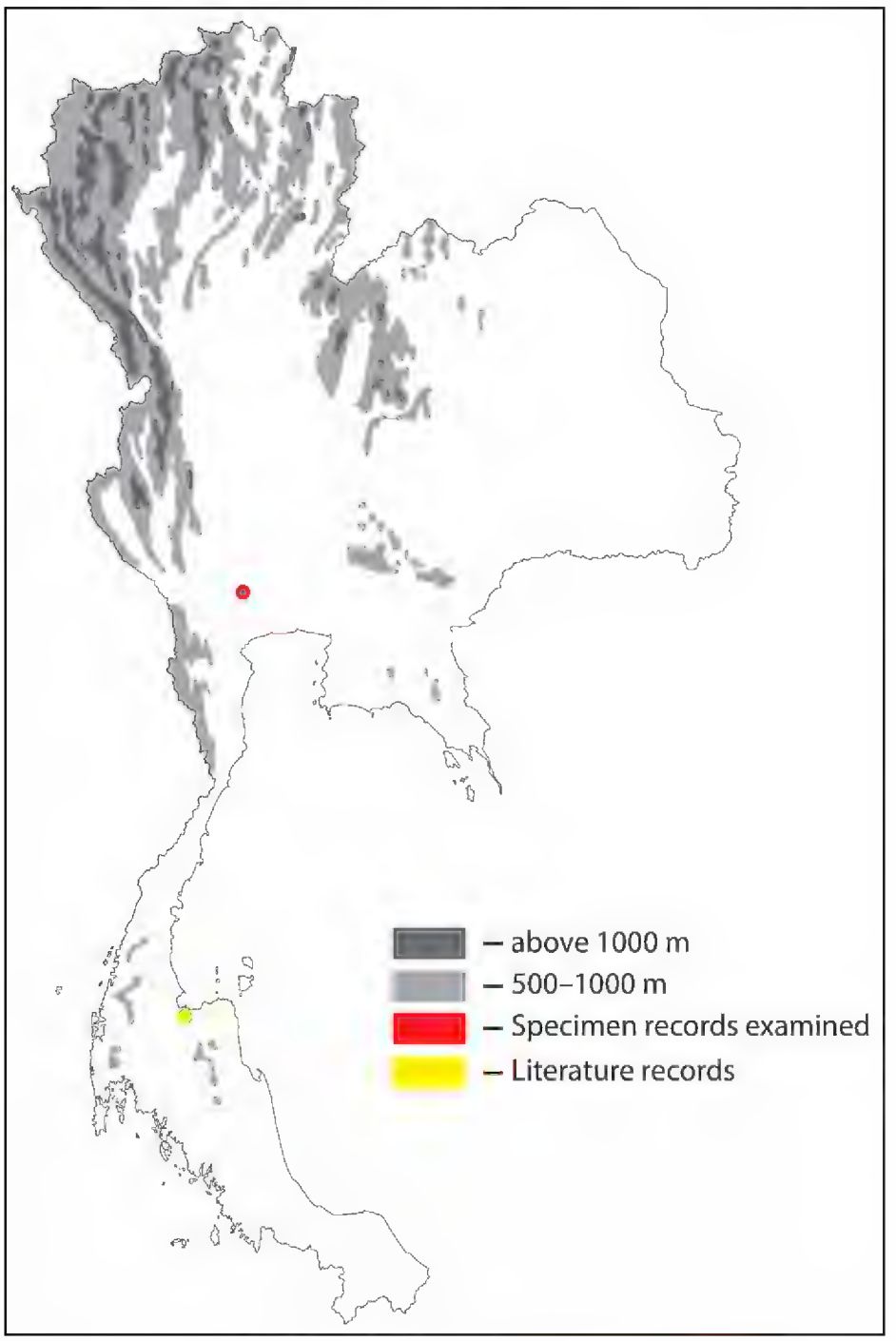


Figure 9. Thai distribution of *Megachile* (*Callomegachile*) *fulvipennis*.

district, Kamphaeng Saen subdistrict, Kasetsart University, Kamphaeng Saen Campus, 20-VIII-1956, coll. Chayuta (leg. NC and NW).

Megachile (*Callomegachile*) *impressa* Friese, 1903

Figs 11, 12

Megachile impressa Friese, 1903: 358. Male holotype (MFNB, not examined) Tenasserim (Kayin: Thandaung), Myanmar.

Diagnosis. The species superficially resembles *M.* (*Callomegachile*) *binghami* Meade-Waldo, 1912, in terms of its overall appearance and size: black hairs on paraocular area;

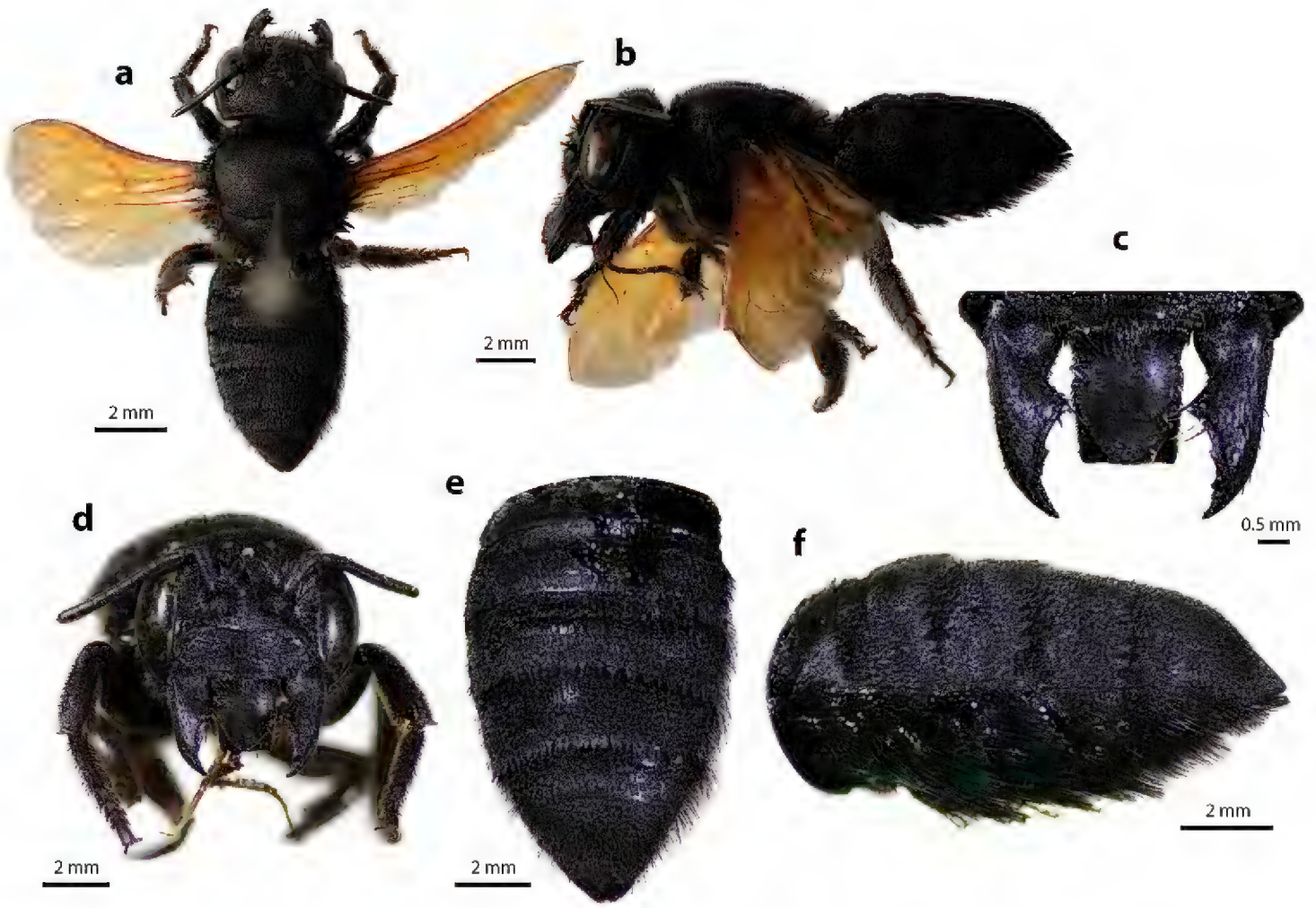


Figure 10. *Megachile* (*Callomegachile*) *fulvipennis* Smith, 1879, female **a** dorsal view **b** lateral view **c** dorsal view of mandible and labrum **d** frontal view **e** dorsal view of metasoma **f** lateral view of metasoma and scopa.

thorax with white hairs except central area of mesoscutum and scutellum; metasomal terga covered with ferruginous hairs; scopa ferruginous except white basal area; apical margin of clypeus with one medioapical tubercle and two lateral tubercles (Fig. 12b, c); meso- and metatarsi with ferruginous hairs (Fig. 12a). These characters are used to associate male and female bees.

Description. ***Female.*** Length. Total body length 14.28–15.90; wingspan 23.40–26.54; fore wing 10.01–11.34. Structure and color. Head black; paraocular area with dense black hairs; central area of clypeus with strong median carina; apical margin of clypeus with medioapical tubercle and two lateral tubercles; subtriangular supraclypeal area with sparse punctures, apical and median area with strong carina; mandible with two stout apical teeth at apex and three small teeth basally, without cutting edge; outer surface of mandible minutely roughened with long black hairs; labrum rectangular, with surface minutely roughened and brimmed with erected long brown hairs along margins, conspicuously at apex; gena with sparse punctures; almost bare vertex with sparse punctures, ID shorter than OD, ID/OD = 0.50 ± 0.01; antennae with ten flagella, first flagellomere wider than long but shorter than the second; body parallel-sided, thorax covers with white hairs except central area of mesoscutum and scutellum; mesoscutum and lower part of mesepisternum with coarsely striate puncture pattern; procoxal base with conspicuous small carina, covered with sparse white hairs; pro- and

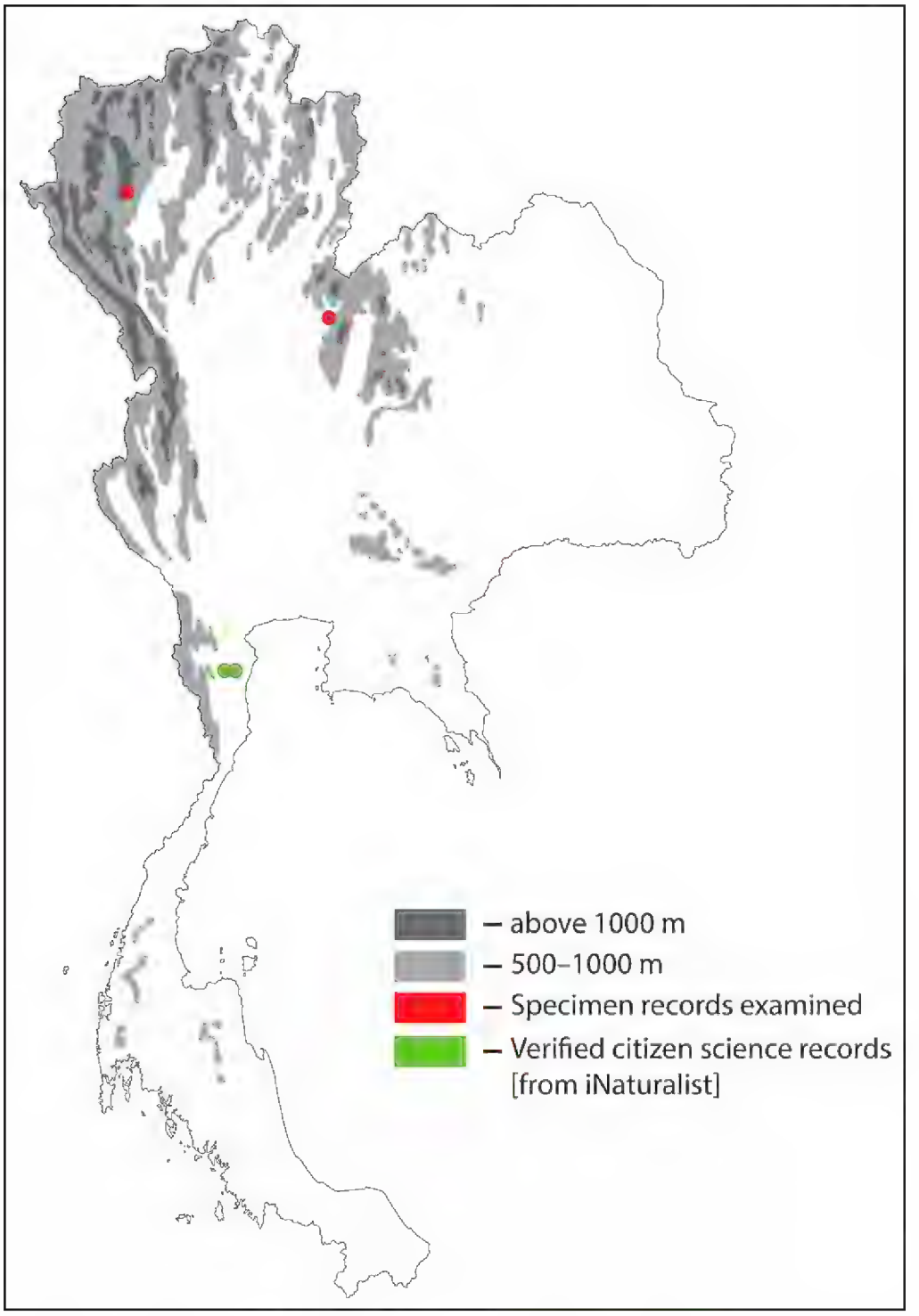


Figure 11. Thai distribution of *Megachile* (*Callomegachile*) *impressa*.

mesotibiae with two spines at apices; metatarsus with one small spine at apex; protarsus covers with dense brown hairs; meso- and metatarsus cover with dense brown hairs on outer side, with dense ferruginous hairs inner side; wing brown with dark brown vein; T1 covers with sparse ferruginous hairs, with sparse punctures; T2–T5 cover with dense ferruginous hairs, dense punctures on pregradular area, sparse punctures on marginal zone; T6 covers with dense ferruginous hairs, with sparse punctures and round shape at apex; scopa ferruginous except the basal area with white.

Literature records. Laos. Houaphan (Ascher and Pickering 2020); Malaysia. Kelantan (Ascher and Pickering 2020); Myanmar. Kayin, Tangdong, Tenasserim. (Friese 1903; Ascher and Pickering 2020). Also recorded based on images on iNaturalist on two occasions from Huai Mae Priang, Kaeng Krachan District, Phetchaburi Province (credit: djhiker 2016; pam-piombino 2017).

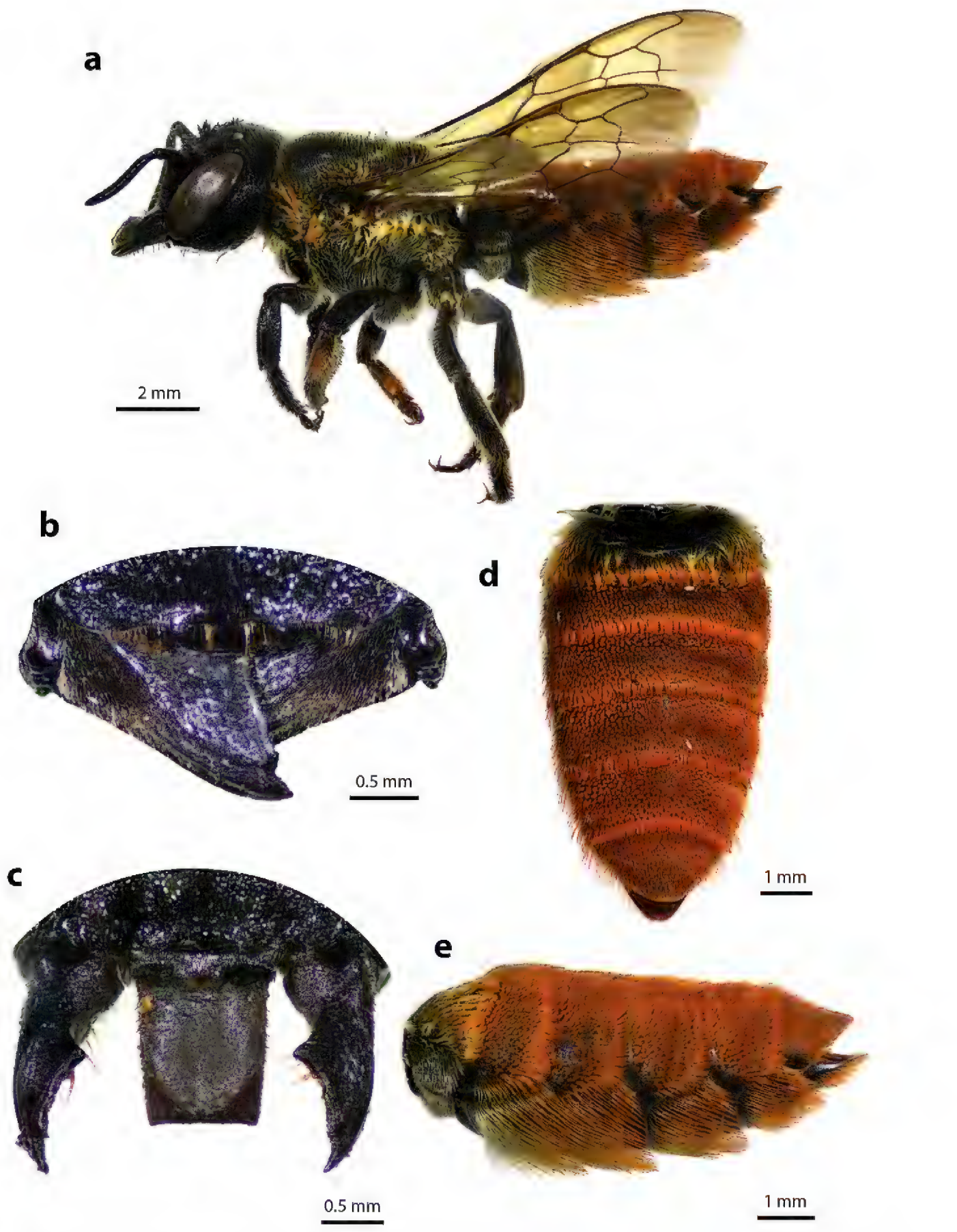


Figure 12. *Megachile* (*Callomegachile*) *impressa* Friese, 1903, female **a** lateral view **b** frontal view **c** clypeus and mandible **d** dorsal view of metasoma **e** lateral view of metasoma.

Material examined. Thailand. Chiang Mai Province: 1♀, Chom Thong district, Doi Inthanon Nat. P., Wildfire Control Station, 18°37'7.0590"N, 98°36'29.7606"E, Alt. 779 m, 20-VII-2015, coll. Warrit et al. (leg. NC and NW). Phitsanulok Province: 2♀, Phuhinrongkla Nat. P., 16°59'49.3008"N, 101°0'40.6772"E, Alt. 1303 m, 17-VI-2017, coll. N. Warrit et al. (leg. NC and NW).

Floral record. Specimens from Phitsanulok province were collected on *Craspedolobium unijugum* (Gagnepain) Z. Wei & Pedley at Phuhinrongkla National Park along with *M. umbripennis* and *Megachile* (*Creightonella*) *fraterna* Smith, 1853.

Comments. In the field, *M. impressa* can be confused with *Megachile* (*Creightonella*) *fraterna* since that species also has a black head and ferruginous hairs on abdomen. However, *M. fraterna* can be easily discriminated by characters in the mandible and cutting edge between interspaces.

Remarks. Known sites for this species are in the highlands.

Megachile (*Callomegachile*) *memecylonae* (Engel, 2011)

Figs 13, 14

Chalicodoma (*Alocanthedon*) *memecylonae* Engel, 2011: 63–67; Male holotype (NHMUK, examined), Penang: Batu Ferringgi, Malaysia.

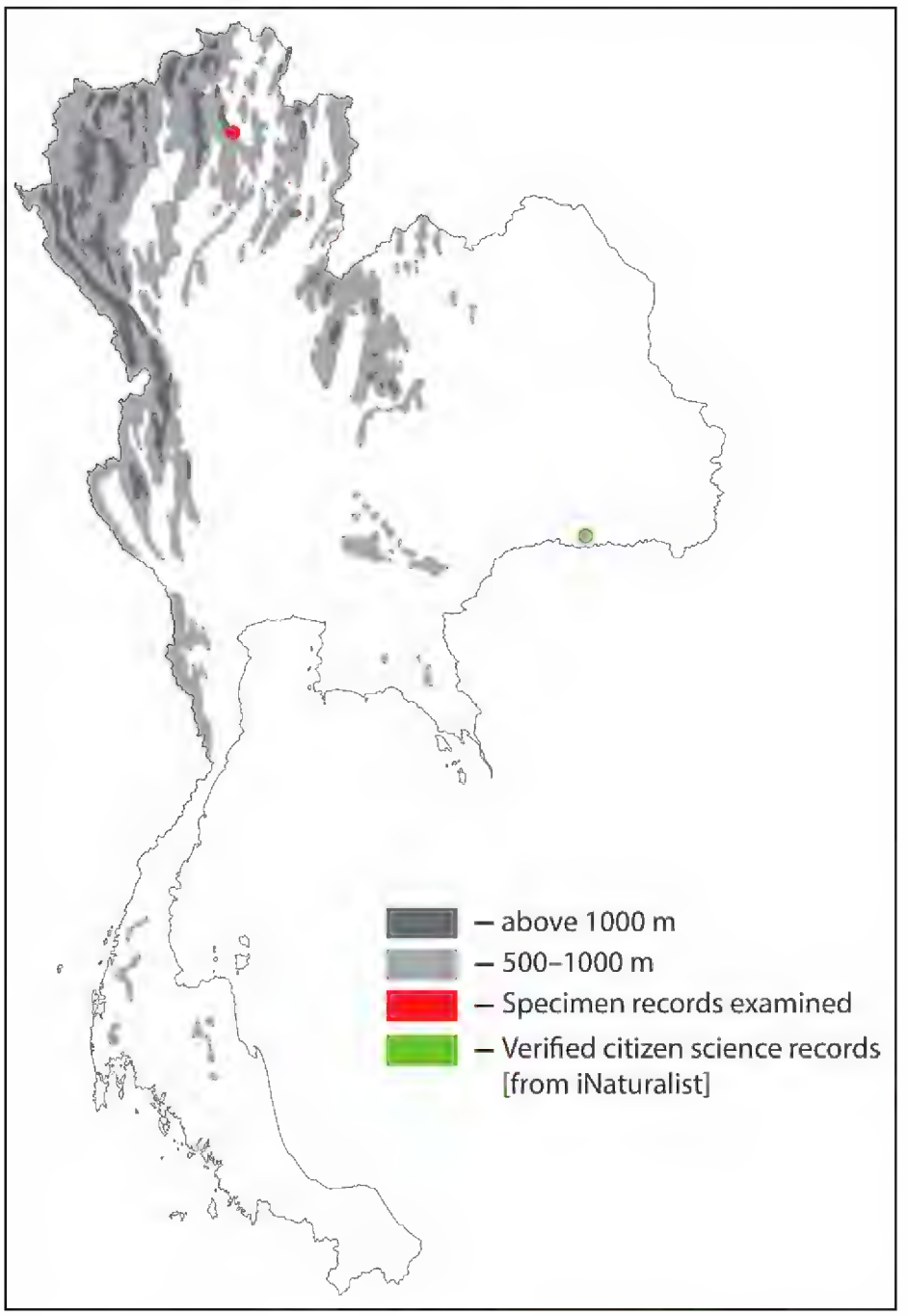


Figure 13. Thai distribution of *Megachile* (*Callomegachile*) *memecylonae*.

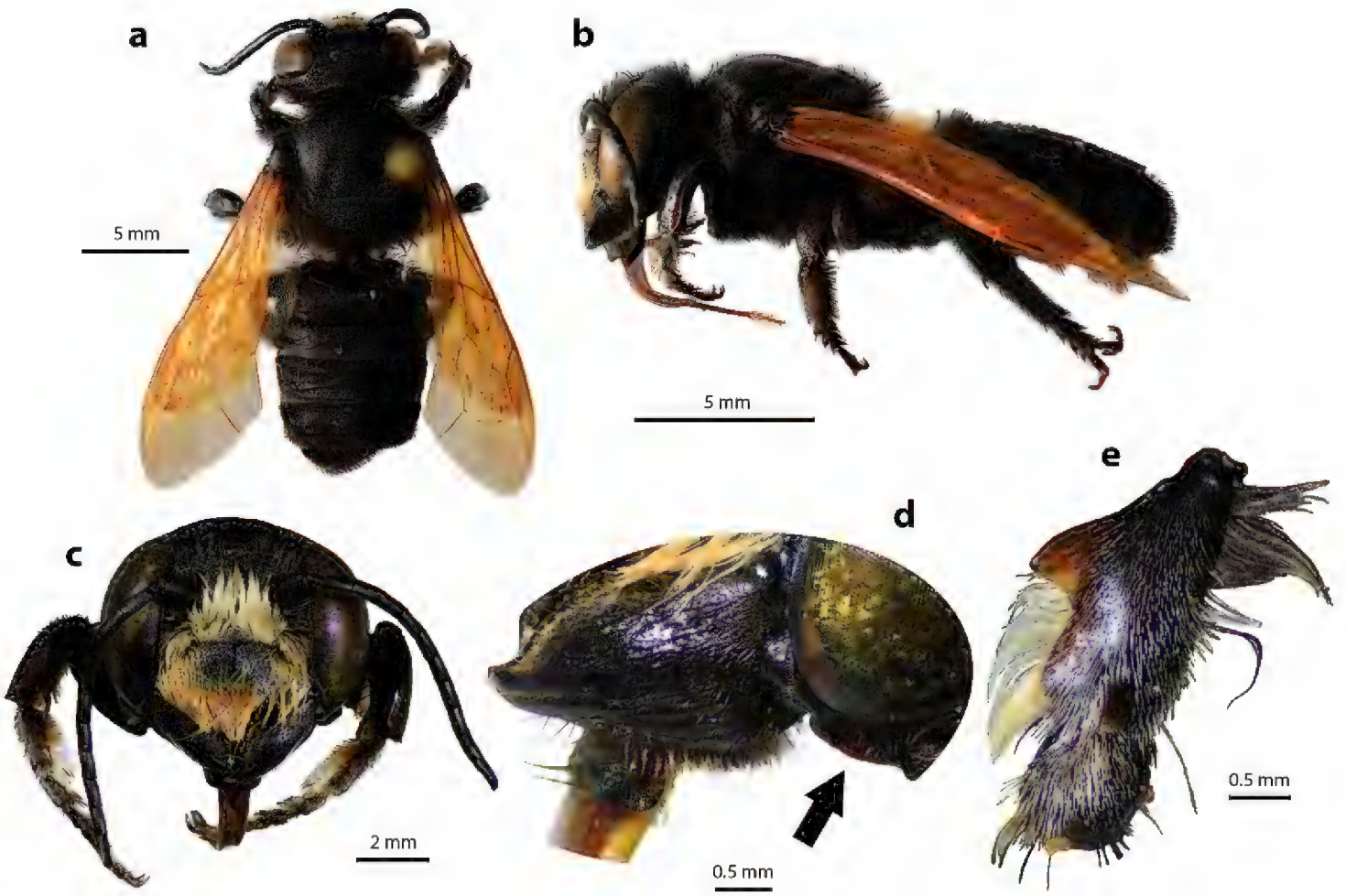


Figure 14. *Megachile* (*Callomegachile*) *memecylonae* (Engel, 2011), male **a** dorsal view **b** lateral view **c** frontal view **d** juxtamandibular flange **e** basitarsi of front leg.

Diagnosis. *Megachile* (*Callomegachile*) *memecylonae* (Engel, 2011) superficially resembles *M.* (*Callomegachile*) *atratiformis* (Meade-Waldo, 1914), in overall appearance and size: large body size (18–19 mm); black body covered with black hairs throughout; yellow wings. Female is easily distinguished by mesoscutum with distinctly transverse wrinkle pattern on disc, posteriorly also with well separated punctures (Engel and Gonzalez 2011). Male can be recognized by median cell of forewings without black setae patch; juxtamandibular flange present (Fig. 14d); basitarsi of pro legs with hook shape (Fig. 14e).

Literature records. Malaysia. Kuala Lumpur, Pahang, Pangkor Island, Penang, Perak, Selangor (Engel and Gonzalez 2011). A photograph on iNaturalist from Buachet, Surin Province may pertain to this species but visual identification in this group is difficult (credit: janescan 2018).

Material examined. Male holotype. Malaysia. "Holotype; B.M. TYPE HYM 17a. 3179; memecylonae, Batu Feringgi; 17 xi 1963 HTP. ø147; H.T. Pagden Coll. B.M. 1971–46; Malaya, Penang, Batu Feringgi, 17 Nov 1963, H T Pagden; Holotype, *Chalicodoma memecylonae* Michael S. Engel; NHMUK 013380270"; Thailand. Phayao Province: 1♂, Mueang district, Mae Ka subdistrict, Phayao University, 01-VI-2012, coll. Warrit et al. (leg. NW).

Remarks. This species was described from Peninsular Malaysia. It is remarkable that the first and only Thai specimen record is from Phayao Province in northern Thailand.

Megachile (*Callomegachile*) *monticola* Smith, 1853

Figs 15, 16

Megachile monticola Smith, 1853: 179. Female syntype (NHMUK, examined).
Megachile felderi Radoszkowski, 1882: 79.
Megachile rhinoceros Mocsáry, 1892: 131.
Megachile samson Cameron, 1897: 128.
Megachile koshunensis Strand, 1913: 60.
Chalicodoma (*Eumegachilana*) *monticola*: Michener, 1965: 192.

Diagnosis. Female can be recognized by its black large body size (20–26 mm); mesosoma and T1 covered with fulvous hairs (Fig. 16a); base of clypeus with large protruding tubercle (Fig. 16b); mandibles elongate with three teeth and small tubercle at base; labrum oblong with lateral impression (Fig. 16c); black scopa.

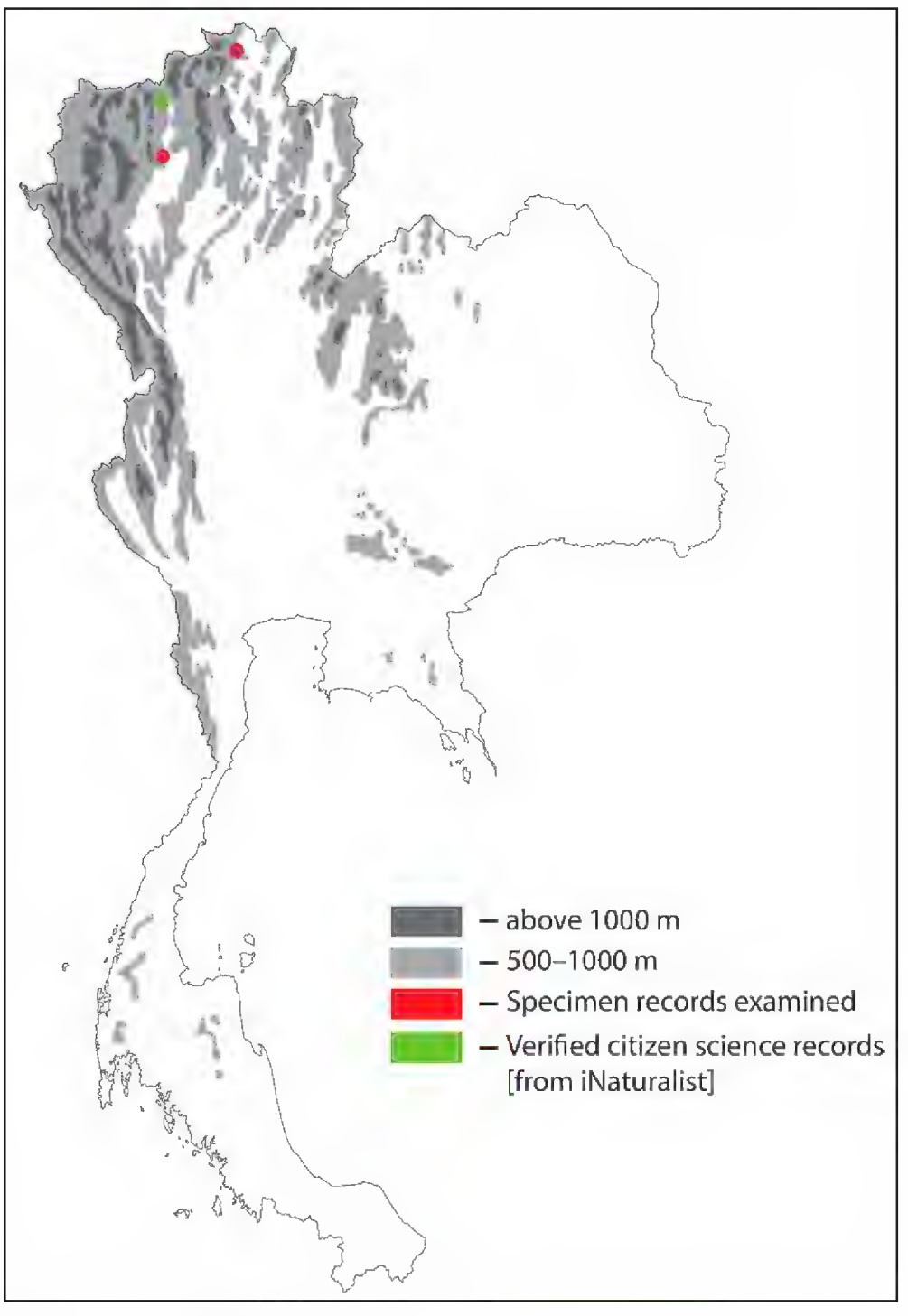


Figure 15. Thai distribution of *Megachile* (*Callomegachile*) *monticola*.

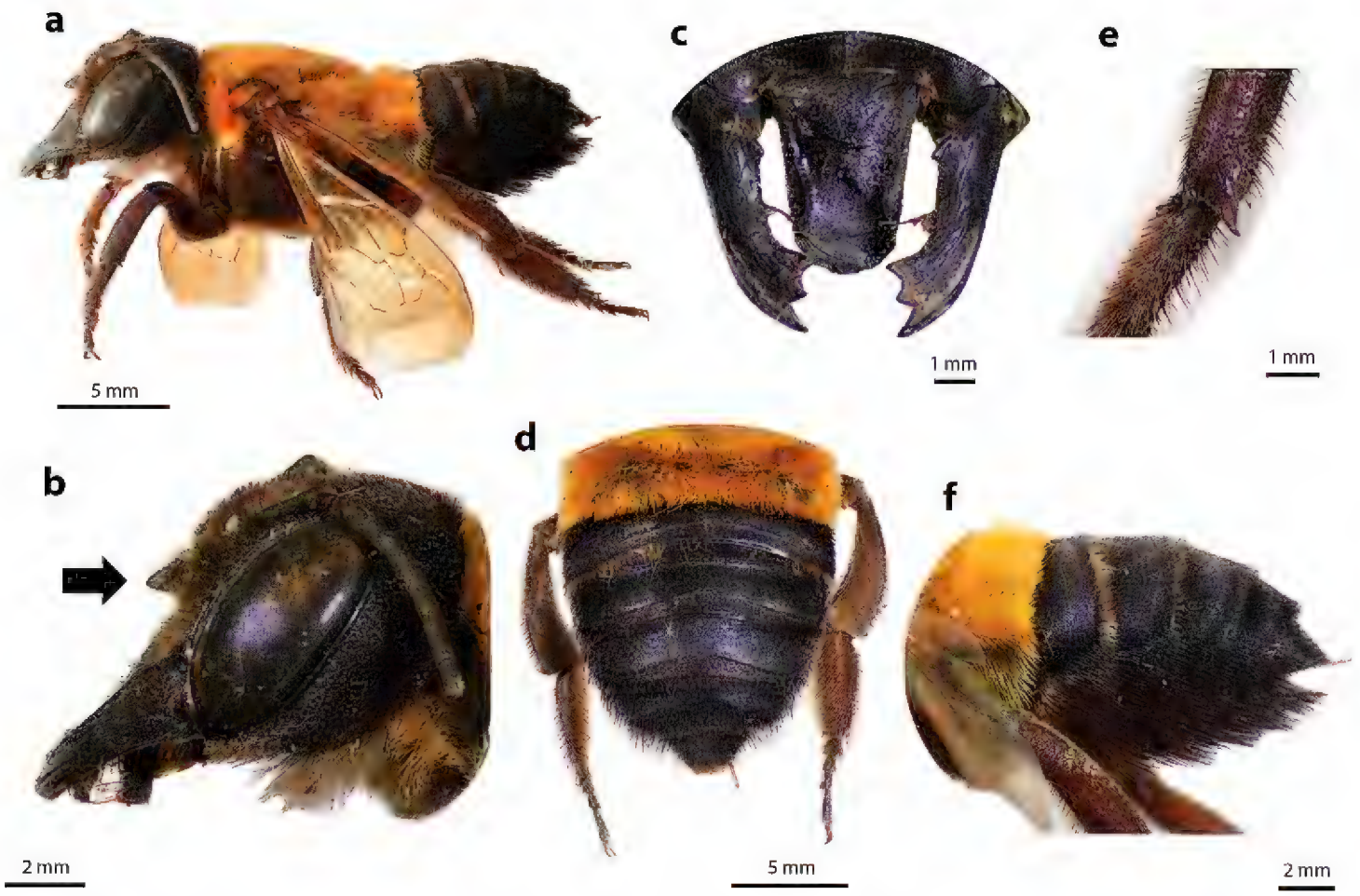


Figure 16. *Megachile* (*Callomegachile*) *monticola* Smith, 1853, female **a** lateral view **b** protruding tubercle at base of clypeus (arrow) **c** frontal view of mandible and labrum **d** dorsal view of metasoma **e** spine at apical tibia **f** lateral view of metasoma and scopa.

Literature records. Bangladesh. Sylhet (Smith 1853; Bingham 1897); China. Anhui, Fujian, Shanghai (Smith 1853); Hong Kong.; India. Assam, Sikkim (Bingham 1897); Indonesia. Lombien Island (Ascher and Pickering 2020); Japan. Okinawa, Uragami (Ascher and Pickering 2020); Myanmar. Tenasserim (Bingham 1897); Taiwan. Taihoku-shu (Ascher and Pickering 2020); Vietnam. Thua Thien-Hue (Ascher and Pickering 2020). Also reported from Chiang Mai Province on iNaturalist (credit: entomokot 2019).

Material examined. Female syntype. "Type; B.M. TYPE HYM. 17. a. 2155; Sylhet, 4[?]7 51; *Megachile monticola*, TYPE, Sm.; monticola Type Sm.; NHMUK 013379845"; Thailand. Chiang Mai Province: 1♀, Mueang district, Chang Phuag subdistrict, Nong Hoe, 17-VII-1996, coll. Adul (leg. NC and NW); 1♀, longan plantation, 10-II-2009, coll. Paveenun (leg. NC and NW); 1♀, 20-IX-1985, coll. Sumrid (leg. NC and NW). Chiang Rai Province: 1♀, Mae Chan district, Mae Chan subdistrict, 14-VIII-1960, coll. unknown (leg. NC and NW).

Megachile (*Callomegachile*) *odontophora* (Engel, 2011)

Figs 17, 18

Chalicodoma (*Alocanthedon*) *odontophorum* Engel, 2011: 55–60; Female paratype (NHMUK, examined) Nakhon Ratchasima, Thailand.

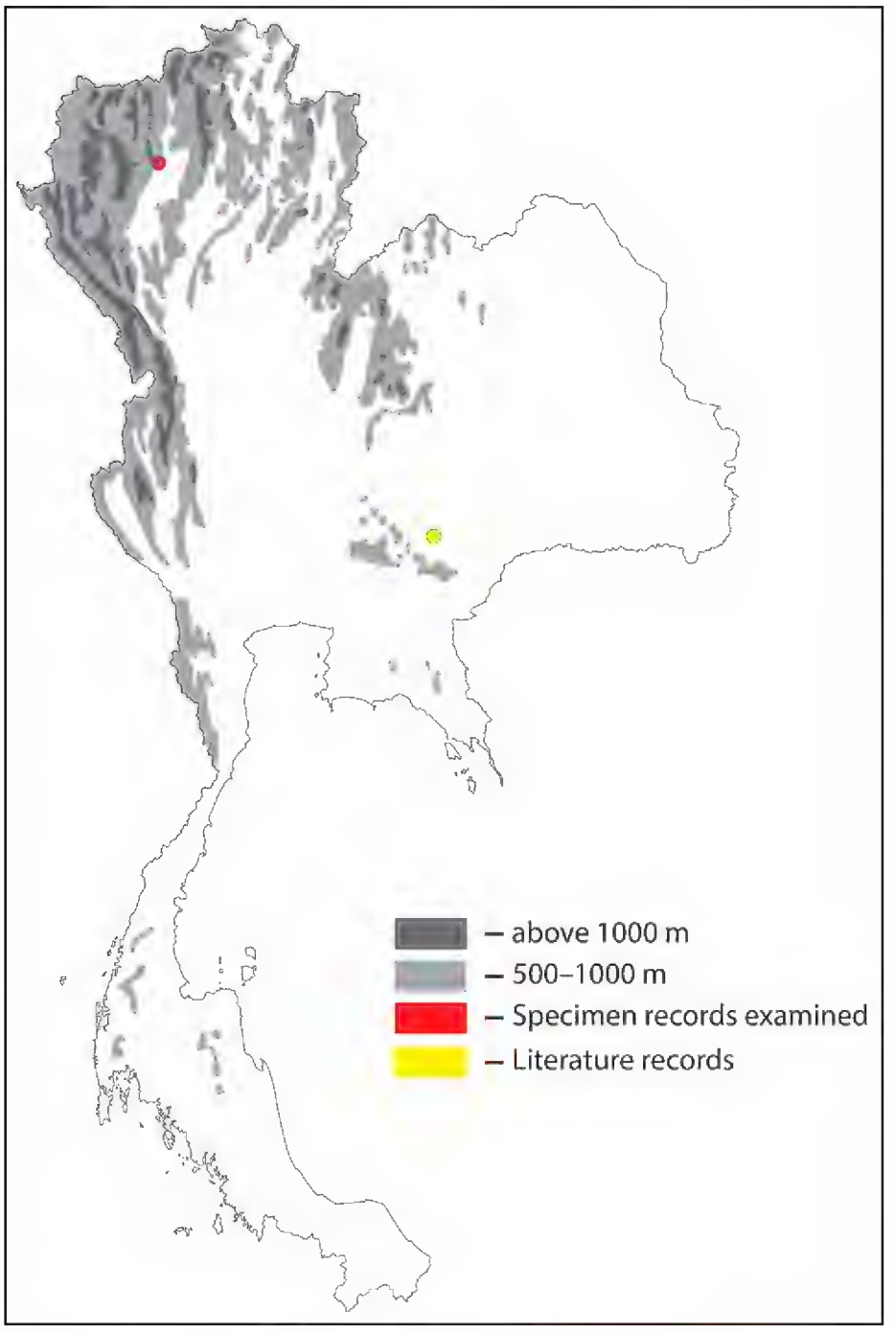


Figure 17. Thai distribution of *Megachile* (*Callomegachile*) *odontophora*.

Diagnosis. Female superficially resembles *M.* (*Callomegachile*) *atratiformis* (Meade-Waldo, 1914) in overall appearance and size: large body size (20–24 mm); black body covered with black hairs throughout; mesoscutum with weak transverse wrinkle pattern on disc, also posteriorly with weakly transverse wrinkle pattern; yellow wings (except apical margin of clypeus with median tubercle (Fig. 18e); mandibles four teeth with three stout apical teeth at apex and small tooth basally; labrum oblong with pointed apical margin and two lateral teeth (Fig. 18d)). Male can be easily recognized by clypeus covered with densely long hairs; forewings with black setae patch on medial cell; modified front tarsi (Engel and Gonzalez 2011).

Literature records. Myanmar. Thaungyin valley (Middle Tenasserim) (Engel and Gonzalez 2011); Thailand. Nakhon Ratchasima (Engel and Gonzalez 2011).

Material examined. Type material. Female paratype. Myanmar. "Middle Tenasserim; Thaungyin [= Moei River] Valley, 5/93, C.T. Bingham; Col. C.T. Bingham 96–30; Paratype, *Chalicodoma odontophorum* Michael S. Engel; NHMUK

Figure 18. *Megachile* (*Callomegachile*) *odontophora* (Engel, 2011), female **a** dorsal view **b** lateral view **c** frontal view **d** frontal view of mandible and labrum **e** tubercle at clypeal margin (arrow) **f** dorsal view of mesoscutum **g** lateral view of metasoma and scopa **h** dorsal view of metasoma.

013380271"; Thailand. Chiang Mai Province: 1♀, 13-VII-2006, coll. M. Rungrote (leg. NC and NW).

Floral record. Engel and Gonzalez (2011) noted the species was captured on *Sindora siamensis* Teijsman & Miquel.

Megachile (*Callomegachile*) *ornata* Smith, 1853

Figs 19, 20

Megachile ornata Smith, 1853: 183; female syntype (NHMUK, examined) Indonesia.
Megachile miniata Bingham, 1896: 199.
Megachile ruficorbis Cockerell, 1927: 6.

Diagnosis. Female can be recognized by its black large body size (17–19 mm); T1–T4 covered with black hairs; T2 with small patch of brick-red hairs laterally; T5–T6 covered with pale light yellow hairs (Fig. 20a); mandible three teeth (Fig. 20b); second spine of pro- and mesotibiae bifurcate (Fig. 20c); metatibiae with spine at apex (Fig. 20d); brick-red scopa.

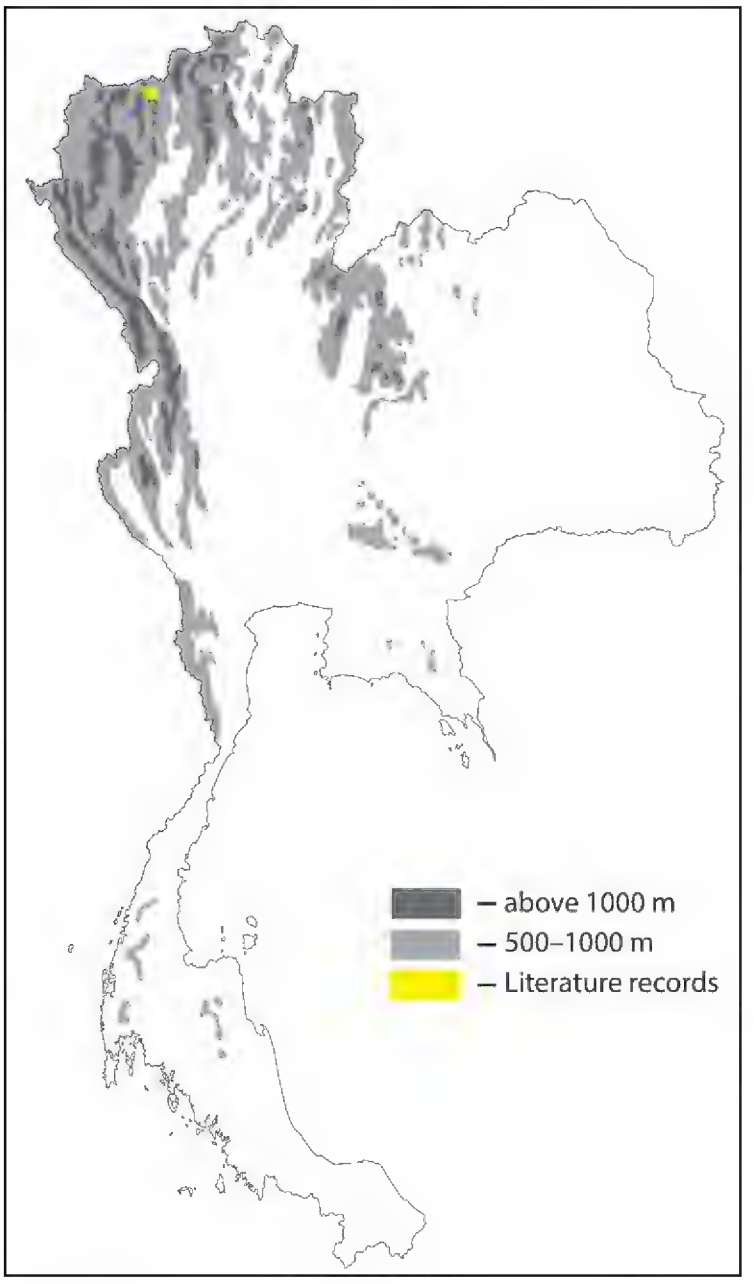


Figure 19. Thai distribution of *Megachile* (*Callomegachile*) *ornata*.

Literature records. Brunei. (Ascher and Pickering 2020); India. (Tadauchi and Tasen 2009); Indonesia. Borneo, Sumatra: including Deli (Kirby 1894; Meade-Waldo 1912; Tadauchi and Tasen 2009; Ascher et al. 2016); Malaysia. Kuala Lumpur, Negeri Sembilan, Pahang, Sabah, Sarawak, Selangor (Cockerell 1927a; Ascher et al. 2016; Ascher and Pickering 2020); Myanmar. (Cockerell 1927a); Nepal. (Tadauchi and Tasen 2009; Ascher and Pickering 2020); Singapore. (Ascher et al. 2016); Thailand. Chiang Mai (Tadauchi and Tasen 2009).

Material examined. Female syntype. Indonesia. "56 43; Locality unknown, pre-1853, Exchanged unit, Mr. Baly, B.M. 1856–43; Syntype, female, *Megachile ornata* Smith, F., 1853:183, det. D. Notton 2018 (ICZN Rec. 73F); B.M. TYPE HYM. 17a. 3215; NHMUK 013379840".

Comments. Trunz et al. 2016's phylogenetic analysis suggested *M. ornata* belongs to a distinct lineage of *Callomegachile* sensu lato.

Floral records. *Megachile* (*Callomegachile*) *ornata* was captured on *Grammatophyllum speciosum* Blume (Ascher et al. 2016).

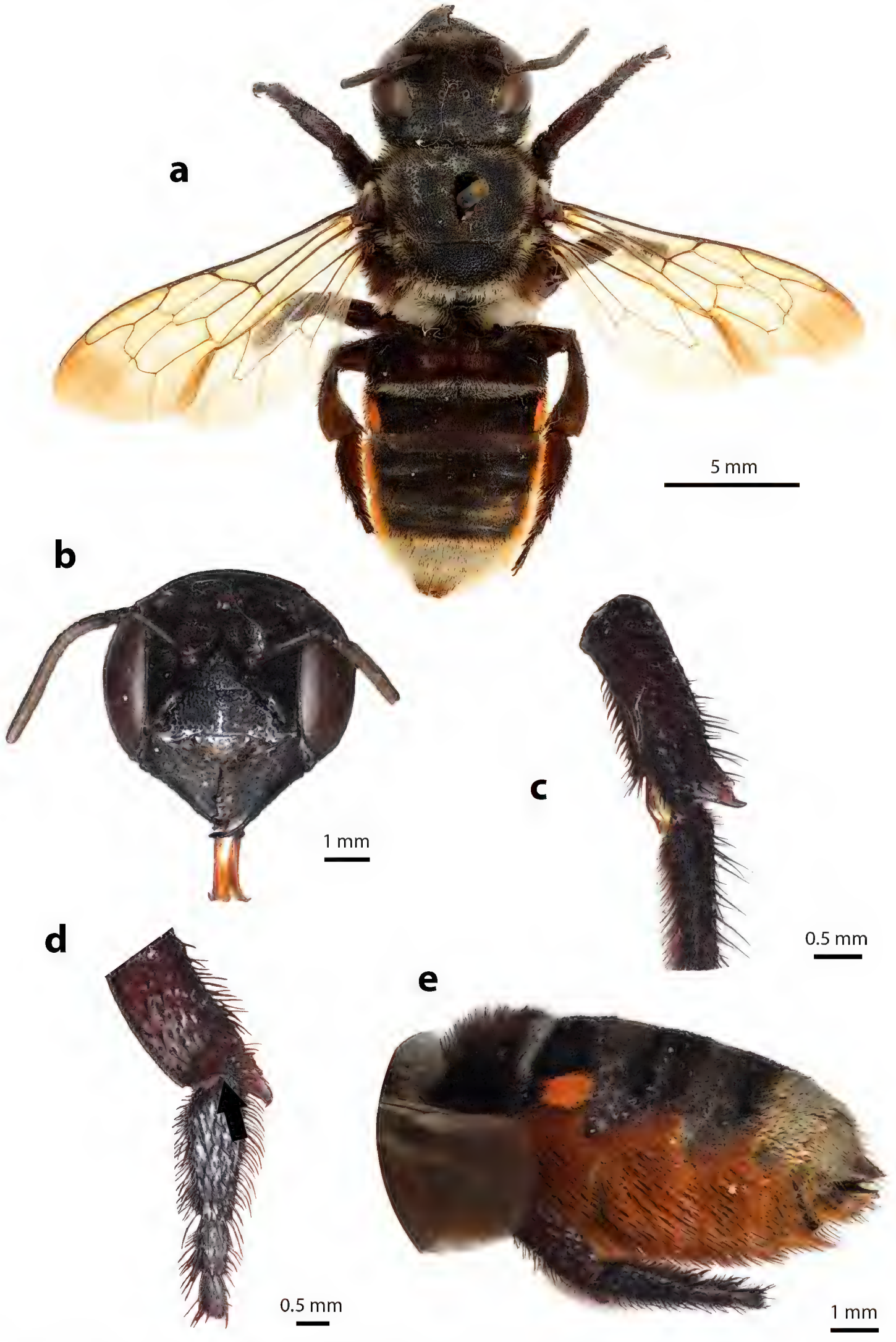


Figure 20. *Megachile* (*Callomegachile*) *ornata* Smith, 1853, female (NHMUK 013379840) **a** dorsal view **b** frontal view **c** spine at front tibia **d** spine at hind tibia **e** lateral view of mesosoma and scopa.

***Megachile* (*Callomegachile*) *parornata* Chatthanabun, Warrit and Ascher, nom. nov.**
Figs 21, 22

Megachile gigas Wu, 2005: 159; preoccupied (junior primary homonym, not *Megachile gigas* Schrottky, 1908, Brazil). Female holotype (erroneously described as male) (IZB, examined) Xiaomengyang, Xishuangbanna, Yunnan, China.

Diagnosis. Female superficially resembles *M.* (*Callomegachile.*) *ornata* Smith, 1853 except T1 covered with black hairs; T2–T5 covered with brick-red hairs; T6 covered with pale yellow hairs (Fig. 22g, h); scopa brick-red.

Redescription. ***Female.*** Length. Total body length 20.00–21.50; wingspan 35.55–38.24; forewing 14.84–16.13. Structure and color. Head black; ventral margin of paraocular area with brown hairs; clypeus trapezoid with rough surface and sparse punctures;

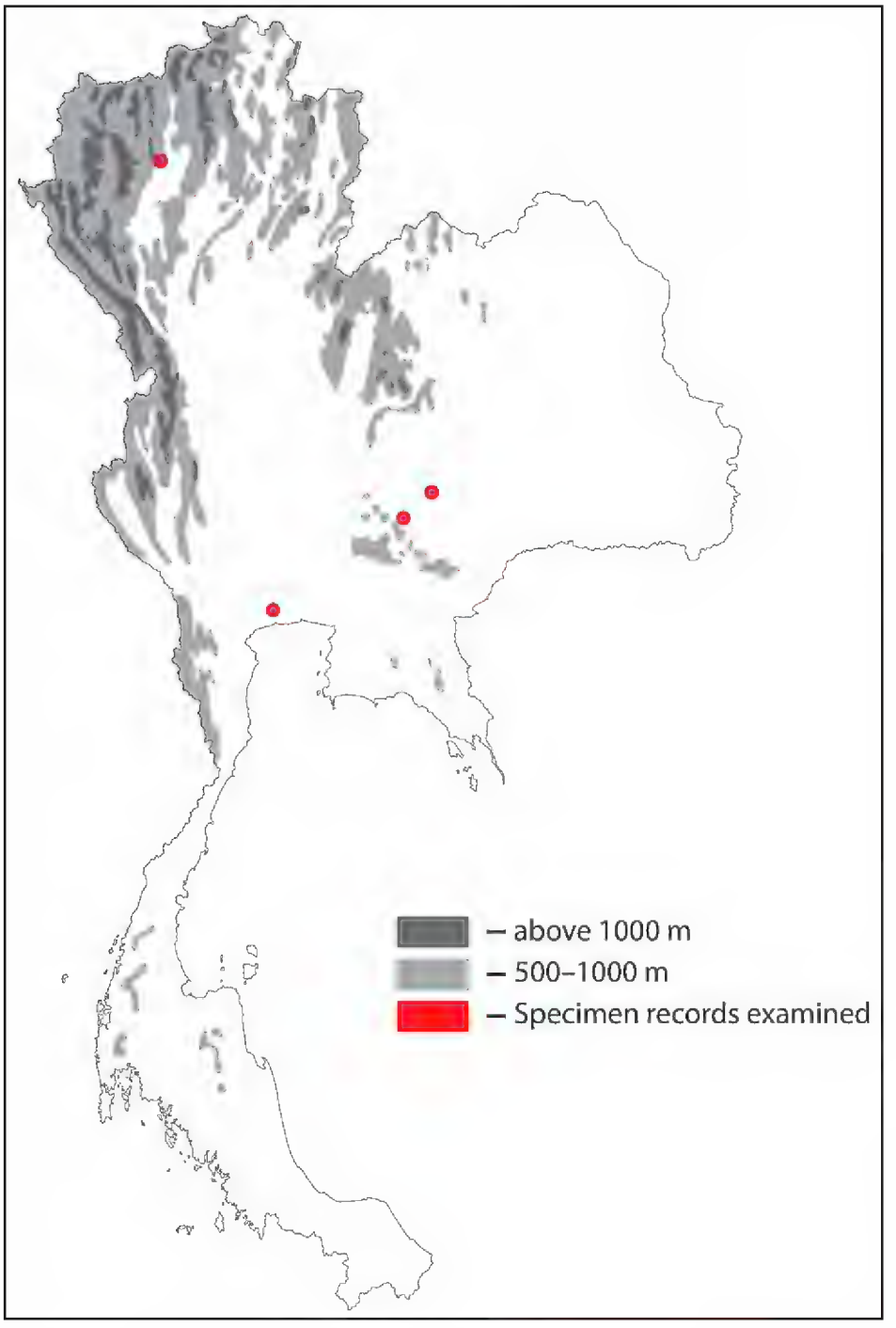


Figure 21. Thai distribution of *Megachile* (*Callomegachile*) *parornata*.

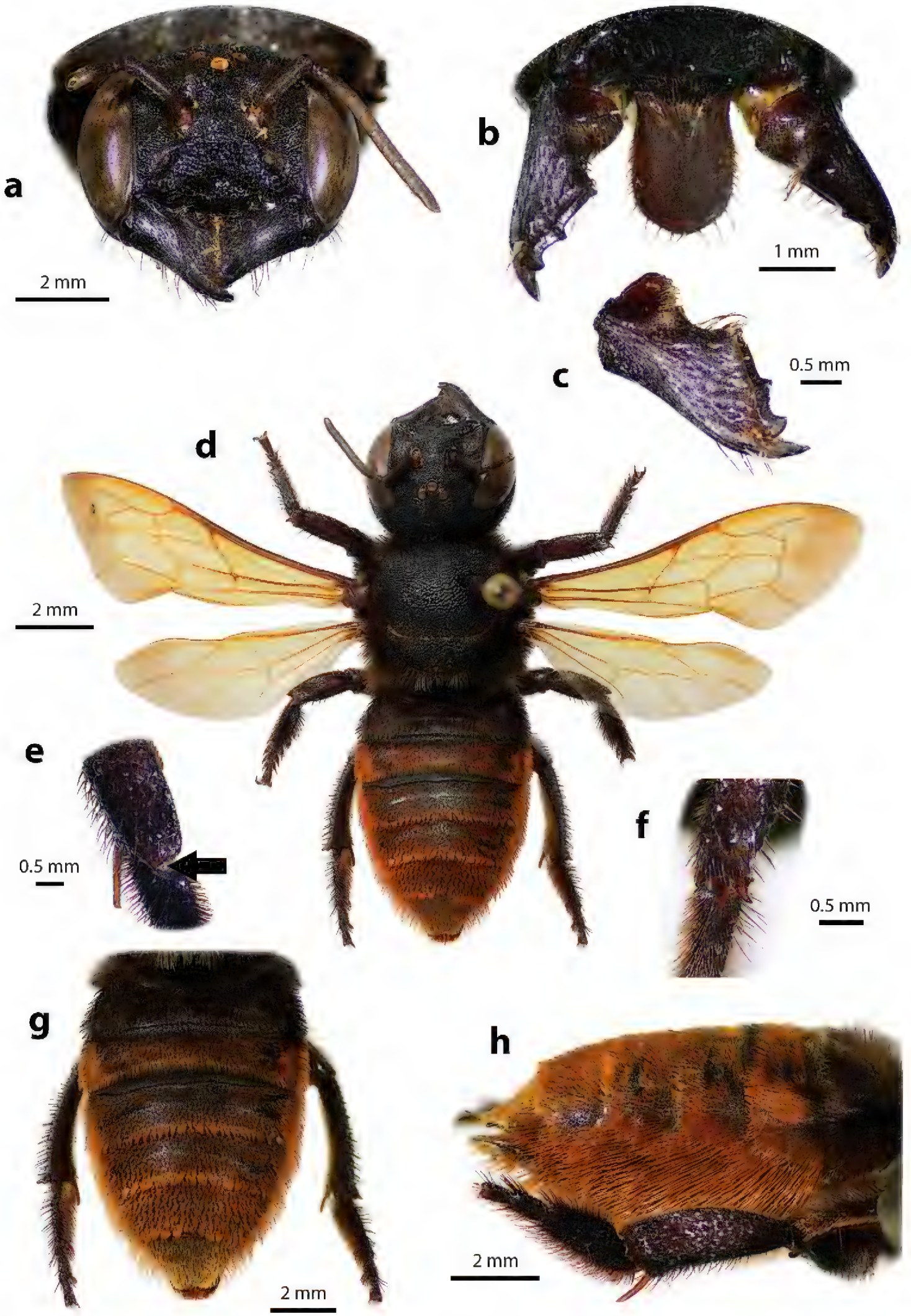


Figure 22. *Megachile* (*Callomegachile*) *parornata* Chatthanabun, Warrit and Ascher, nom. nov., female **a** frontal view **b** labrum and mandibles **c** mandible **d** dorsal view **e** spine on hind tibia **f** spine on front tibia **g** dorsal view of metasoma **h** lateral view of metasoma and scopa.

supraclypeal area convex and subtriangular with rough surface and sparse punctures; mandible with three teeth, without cutting edge; outer surface of mandible minutely roughened with long brown hairs; labrum length twice as long as wide with round apex, surface minutely convex and rough with erect long brown hairs at apex; gena with sparse punctures; bare vertex with sparse punctures, ID shorter than OD, ID/OD = 0.28 ± 0.01; antennae with eleven flagella, first flagellomere wider than long, shorter than the second; body parallel-sided; scutum and scutellum hairless except anterior margin of scutum with brown hairs; lower part of metathorax with white hairs; scutum and lower part of mesepisternum with coarsely striate puncture pattern; procoxa covers with brown hairs; pro- and mesotibiae with two apical spines, mesotibial spine bifurcate; apex of metatibiae with spine at apex; pro- and mesotarsus with short brown hairs; metatarsus with dense short fulvous hairs inner side and short brown hairs outer side; forewing length yellow hyaline with yellowish-brown vein; T1 covers with black hairs; T2–T5 cover with brick-red hairs; T6 covers with pale yellow hairs, round apex; scopa fulvous-red.

Male. Unknown.

Literature records. China. Yunnan (Wu 2005); Vietnam. Hoa-Binh, Vinh-Quang (Wu 2005).

Material examined. Female holotype (erroneously described as male). China. "Yunnan, Xishuangbanna, Xiaomengyang (22°N, 100.8°E), 850 m; 1957. IX. 6, collected by Zang Ling-Chao; Holotype; female, *Megachile* (*Callomegachile*) *gigas* Wu, 2005; det. Y. R. Wu; IOZ(E) 210406"; Thailand (new record). Bangkok Province: 1♀, Dusit, 8-IX-1968, coll. Patchanee (leg. NC and NW). Chiang Mai Province: 1♀, Meuang district, Faculty of Agriculture, 4-VIII-1981, coll. Vijit (leg. NC and NW); 1♀, Meuang district, Chiang Mai University, 6-VIII-1981, coll. Sumrid (leg. NC and NW). Nakhon Ratchasima Province: 1♀, 30-VI-1962, coll. unknown (leg. NC and NW); 1♀, Faculty of Forestry, 10-VII-1968, coll. K. Vajropala (leg. NC and NW).

Etymology. The species name refers to the close resemblance to *M. ornata*.

Remarks. The wide published distribution of *M. ornata* from Nepal to the Indonesian Archipelago raises a question regarding whether this is a single species or a species complex. Since the type material of *M. ornata* was collected from Sumatra, Indonesia, specimens reported under this name from other mainland Asian countries should be re-examined. Furthermore, whereas no additional specimens of *M. parornata* were collected and deposited in NHMCU-BSRU and CMU since 1968, Tadauchi and Tasen (2009) recorded one specimens of *M. ornata* from Chiang Mai province (not seen by us). Until, male specimens of both *M. parornata* and *M. ornata* are collected and studied, we are proposing *M. parornata* to be a separate species from *M. ornata*.

Megachile (*Callomegachile*) *tuberculata* Smith, 1858

Figs 23, 24

Megachile tuberculata Smith, 1858: 46. Female syntype (NHMUK, examined) Borneo, Malaysia.

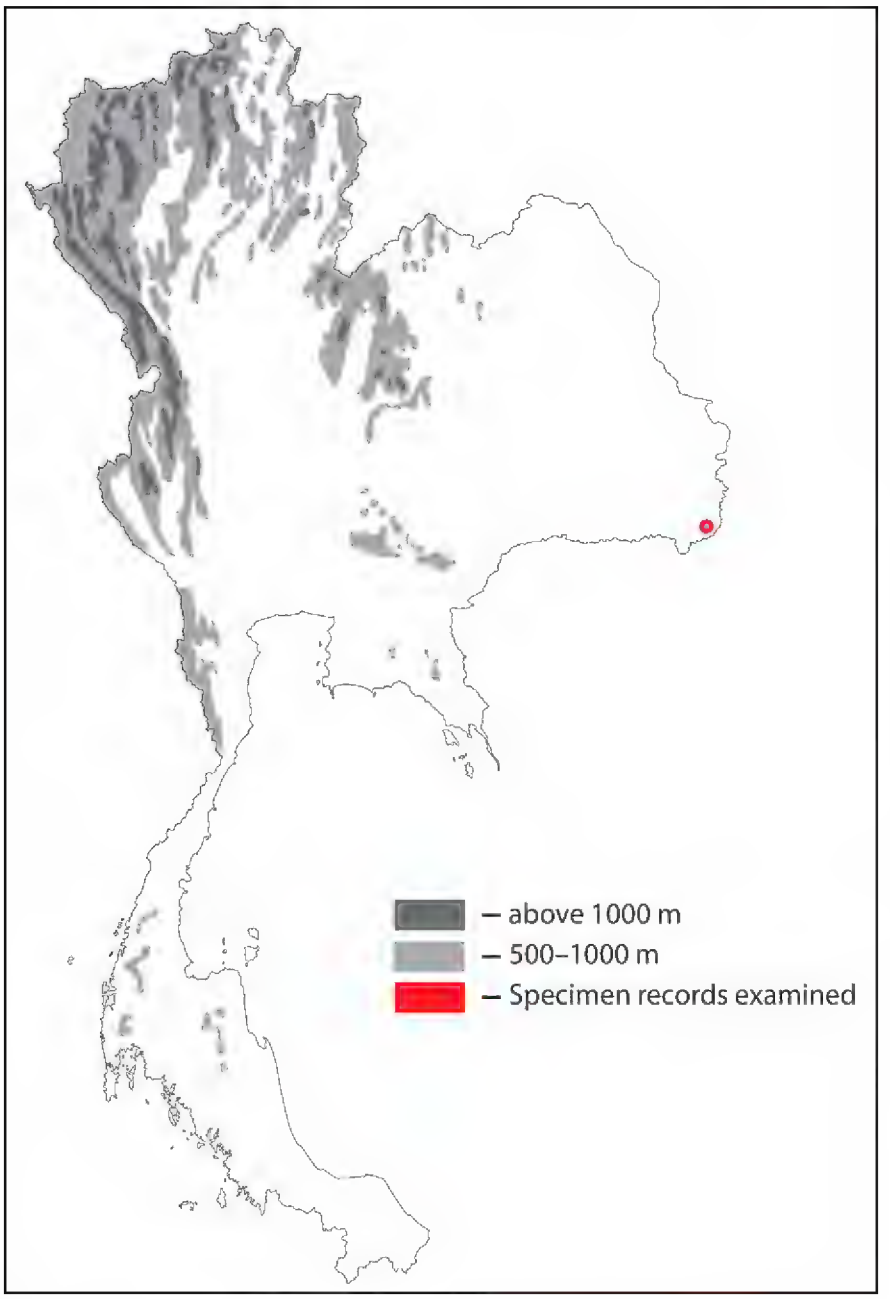


Figure 23. Thai distribution of *Megachile* (*Callomegachile*) *tuberculata*.

Megachile longipalpis Radoszkowski, 1882: 78 [doubtful synonymy].
Chalicodoma (*Eumegachilana*) *tuberculatum*: Michener, 1965: 192.

Diagnosis. Female can be recognized by its large body size (21–24 mm); black body covered with black hairs throughout (Fig. 24a); base of clypeus with large protruding tubercle; mandibles elongate with three teeth and small tubercle at base (Fig. 24c); yellow wings; black scopa.

Literature records. India. Sikkim (Ascher et al. 2016); Indonesia. Java, Sumatera Barat (Ascher et al. 2016); Myanmar. Mergui Archipelago, Bago Yoma (Bingham 1890, 1897); Malaysia. Johor, Negeri Sembilan, Pahang, Perak, Sabah, Sarawak, Selangor, Terengganu, (Smith 1858; Bingham 1890, 1897; Dover 1929; Ascher et al. 2016); Philippines. (The Philippines record based on the type of *M. longipalpis* Radoszkowski, 1882 is considerably outside the verified range for this species as presently understood, so this synonymy should be re-examined); Singapore. (Bingham 1897; Ascher et al. 2016).

Material examined. Female syntype. Malaysia. "Type; B.M. TYPE HYM. 17a. 2840; SAR.; *Megachile tuberculata* Sm. 1857 not 1879; NHMUK 013379846"; Thai-

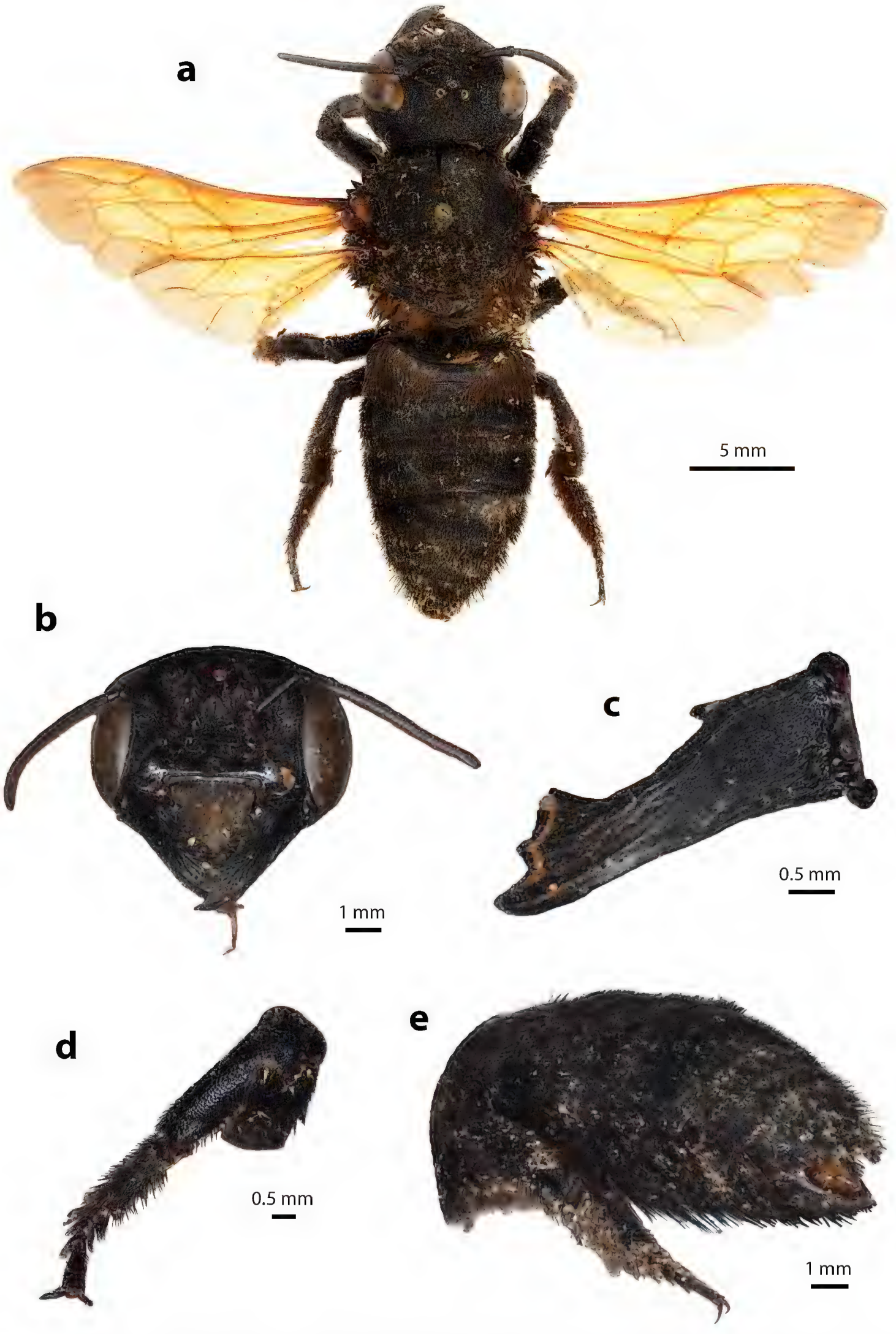


Figure 24. *Megachile* (*Callomegachile*) *tuberculata* Smith, 1858, female (NHMUK 013379846) **a** dorsal view **b** frontal view **c** lateral view of mandible **d** front leg **e** lateral view of metasoma and scopa.

LAND (new record). Ubon Ratchathani Province: 1♀, Na Chaluai district, Phu Jong Nayoy Nat. P., Phalan Pa Chad, 14°26'7.8066"N, 105°15'34.7394"E, Alt. 247.17 m, 6-XI-2019, coll. Traiyasut et al. (leg. NC and NW).

Floral records. *Megachile* (*Callomegachile*) *tuberculata* was photographed visiting and collecting pollens from *Psophocarpus tetragonolobus* (L.) D.C. (Soh et al. 2017), also captured on *Grammatophyllum speciosum* Blume (Ascher et al. 2016).

Comments. The single Thai record is from far to the northeast of the Sundaic Region.

Megachile (*Callomegachile*) *umbripennis* Smith, 1853

Figs 25–29

Megachile umbripennis Smith, 1853: 175. Female syntype (NHMUK, examined) Nepal [as Nepaul].

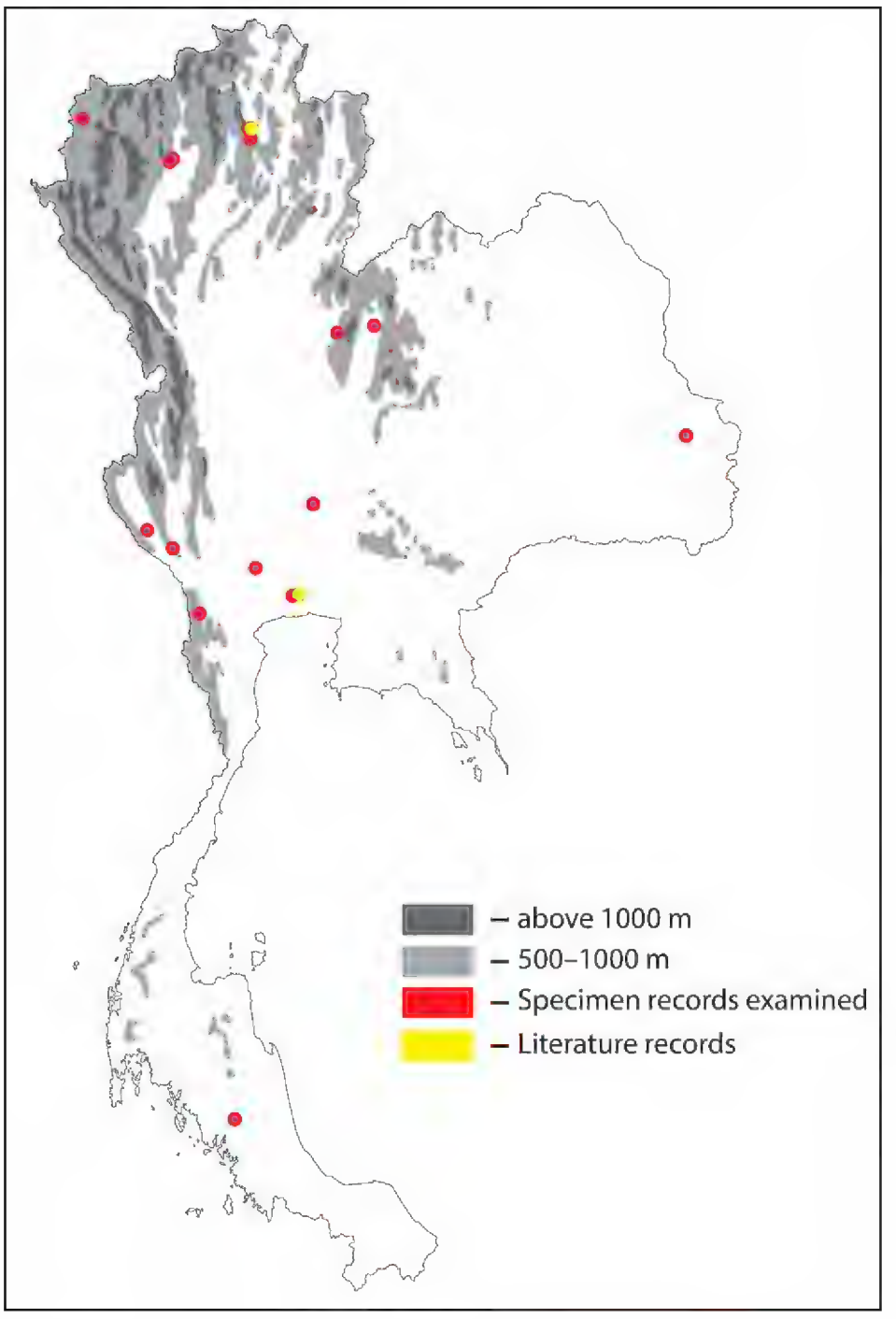


Figure 25. Thai distribution of *Megachile* (*Callomegachile*) *umbripennis*.

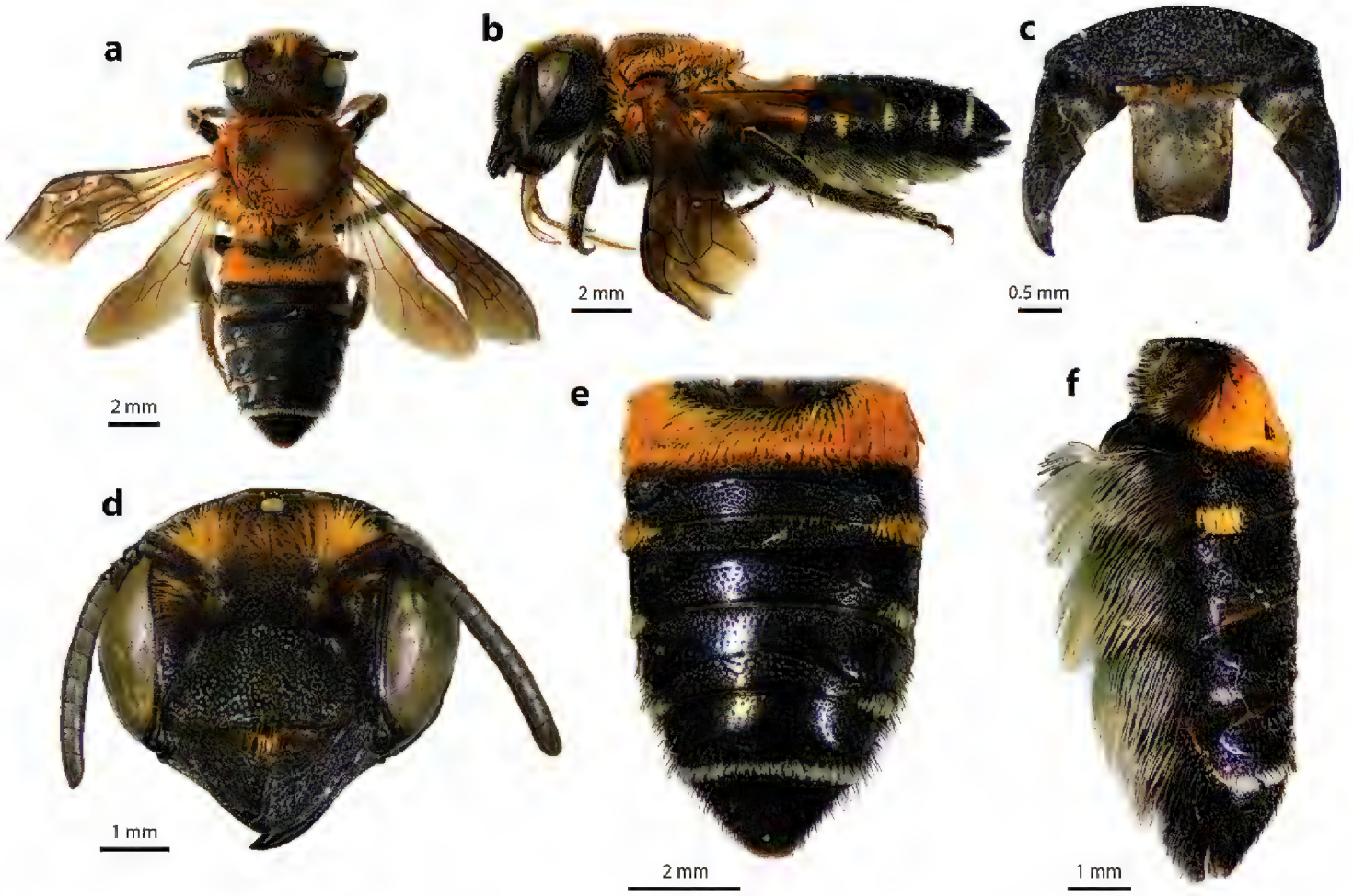


Figure 26. *Megachile* (*Callomegachile*) *umbripennis* Smith, 1853, female **a** dorsal view **b** lateral view **c** frontal view of mandible and labrum **d** frontal view **e** dorsal view of metasoma **f** lateral view of metasoma and scopa.

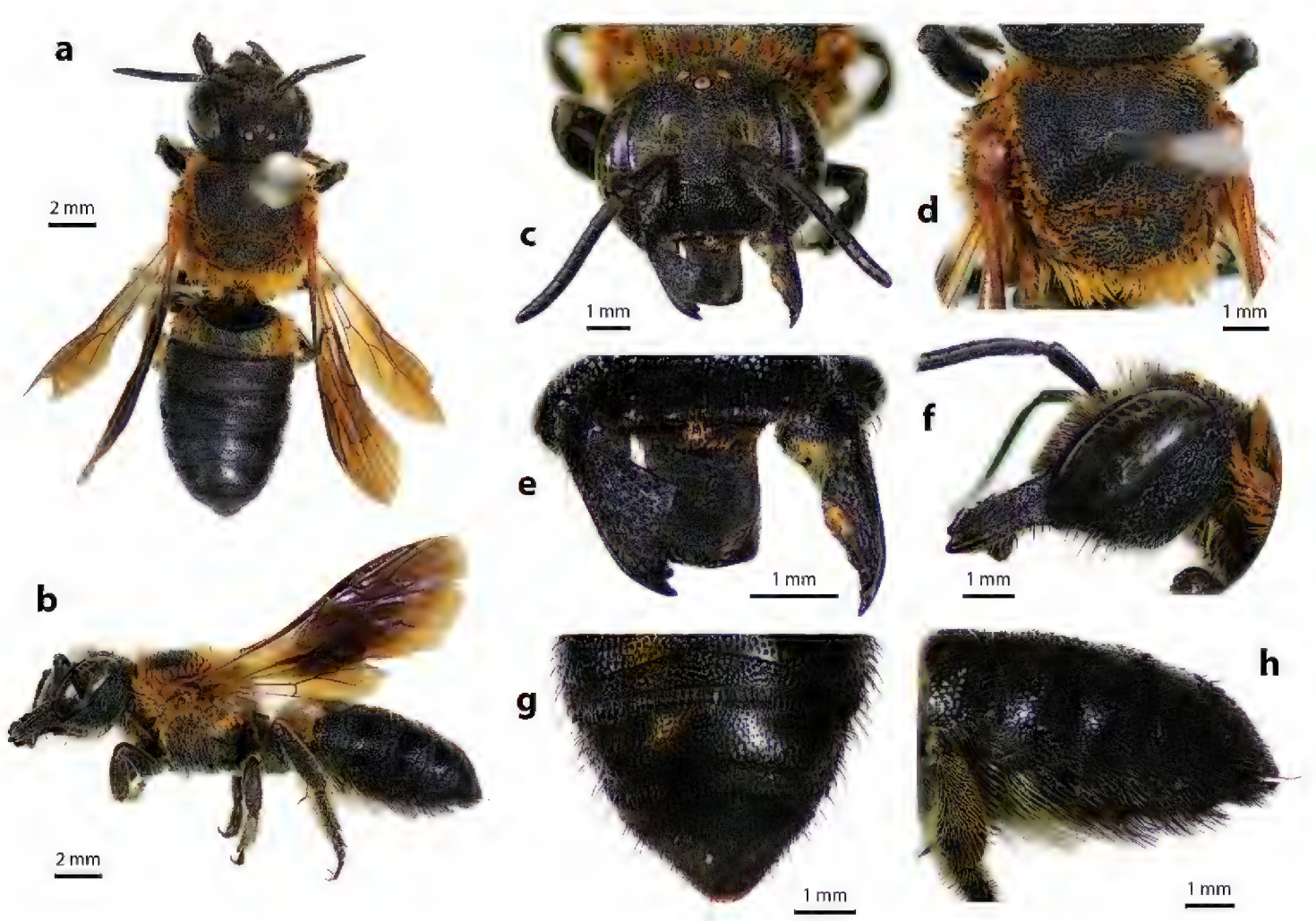


Figure 27. *Megachile* (*Callomegachile*) *umbripennis* Smith, 1853 (BSRU AA-4620), female **a** dorsal view **b** lateral view **c** frontal view **d** dorsal view of mesoscutum **e** clypeus and mandible **f** lateral view of mandible **g** T6 **h** lateral view of metasoma showing scopa.

Megachile schauinslandi Alfken, 1898: 340.
Megachile domesticum Perkins, 1899: 114, nomen nudum.
Megachile umbripennis var *atriventris* Friese, 1903: 357.
Megachile aureobasis Cockerell, 1919: 198.
Megachile (*Eumegachile*) *umbripennis*: Krombein, 1950: 125.
Chalicodoma (*Callomegachile*) *umbripennis*: Michener, 1965: 191.

Diagnosis. Female superficially resembles leafcutter bee *M.* (*Aethomegachile*) *laticeps* Smith, 1853, in terms of its overall appearance and size: mesosoma and propodeal triangle with fulvous hairs, except vertex and disc area of mesoscutum covered with fulvous hairs (Fig. 26a); T2–T4 with tuft fulvous hairs laterally; T5 with white hair band (Fig. 26e). Male is similar to female except apical margin of clypeus covered with hairs; mandibles three teeth (Fig. 28b, c).

Literature records. American Samoa; China. Aitutaki, Canton, Fujian, Guandong, Sichuan, Yunnan (Ascher et al. 2016); Fiji. (Davies et al. 2013; Ascher et al. 2016); French Polynesia. Mo'orea, Society Islands, Tahiti (Ascher et al. 2016); Hong Kong. (Ascher et al. 2016); India. Chandigarh, Haryana, Sikkim, Tamil Nadu (Bingham 1897; Ascher et al. 2016); Laos. Vientiane (Ascher et al. 2016); Malaysia. Kelantan, Kuala Lumpur, Pahang, Sarawak, Selangor (Smith 1858; Ascher et al. 2016); Mariana Islands. San Vicente; Myanmar. Tenasserim (Bingham 1897; Ascher et al. 2016); Nepal. (Smith 1853, 1858; Bingham 1897; Ascher et al. 2016); New Caledonia. (Ascher et al. 2016); Northern Mariana Islands. (Ascher et al. 2016); Singapore. (Ascher et al. 2016); Sri Lanka. Matale (Ascher et al. 2016); Cook Islands. Aitutaki, Rarotonga, Mangaia (Kuhlmann 2006; Ascher et al. 2016); Tonga. (Ascher et al. 2016); USA. Florida, Hawaii, Kauai, Midway, Maui, Molokai, Oahu (Ascher et al. 2016); Vietnam. Ha Giang (Ascher and Pickering 2020).

Material examined. Female syntype. Nepal. "Type; B.M. TYPE HYM. 17. a. 2160; Hardwicke Bequest; Nepal [as Nepaul]; umbripennis, Type, Sm.; *Megachile umbripennis* TYPE. Sm.; NHMUK 013380267"; Thailand. Chiang Mai Province: 1♀, 16♂, Mueang district, Mae Hia subdistrict, Mae Hia Agricultural Research, Demonstrative and Training Center, 18°45'51.1272"N, 98°55'39.6192"E, Alt. 232 m, 19-VII-2015, coll. Warrit et al. (leg. NC and NW). Kanchanaburi Province: 1♀, 19♂, Sai Yok district, Wang Krachae subdistrict, 14°9'56.7678"N, 98°55'39.6192"E, Alt. 232 m, 24-VI-2016, coll. Warrit et al. (leg. NC and NW); 8♂, Sai Yok district, Wang Krachae subdistrict, 14°11'6.5724"N, 99°3'6.9258"E, Alt. 102.30 m, 24-VI-2016, coll. Warrit et al. (leg. NC and NW); 1♀, Sai Yok district, Sai Yok Yai National Park, 14°27'16.4118"N, 98°51'40.4928"E, Alt. 49.17 m, 24-VI-2016, coll. Warrit et al. (leg. NC and NW). Mae Hong Son Province: 1♀, Pang Ung, Pang Tong Under Royal Forest Park 2, 19°29'58.3008"N, 97°54'42.1014"E, Alt. 1,164 m, 10-XII-2015, coll. Warrit et al. (leg. NC and NW). Nakhon Pathom Province: 1♀, Kamphaeng Saen district, Kamphaeng Saen subdistrict, Kasetsart University, Kamphaeng Saen Campus, 22-II-2000, coll. Sokroh (leg. NC and NW); 1♀, Kamphaeng Saen district, Kamphaeng Saen subdistrict, Kasetsart University, Kamphaeng Saen Campus, 22-II-2003, coll. Kittisak (leg. NC and NW); 2♂, Kamphaeng Saen district, 13°44'58.3908"N, 99°52'33.1242"E, Alt. 14 m, 10-VII-2015, coll. Warrit et al. (leg. NC

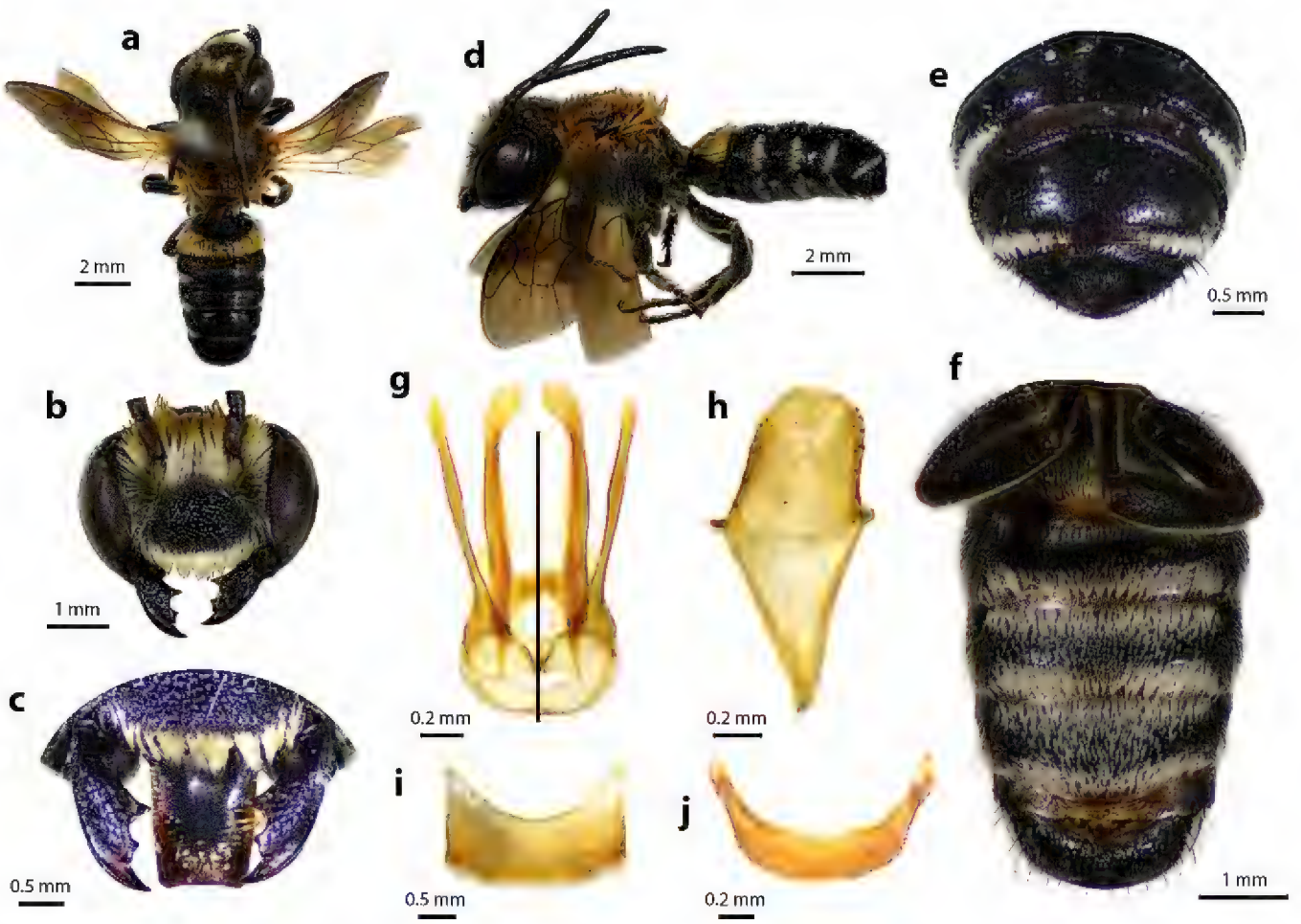


Figure 28. *Megachile* (*Callomegachile*) *umbripennis* Smith, 1853, male **a** dorsal view **b** frontal view **c** frontal view of mandible and labrum **d** lateral view **e** frontal view of T7 **f** ventral view of metasomal sterna **g** dorsal (left) and ventral (right) views of penis **h** dorsal view of S8 **i** S5 **j** T7.

and NW). Phayao Province: 1♀, 4♂, Mueang district, Maeka subdistrict, Phayao University, 01-VI-2012, coll. Warrit et al. (leg. NC and NW); 1♀, 28-I-2014, coll. S. Yutham (leg. NC and NW). Phetchabun Province: 2♂, Lomsak district, Bungkla subdistrict, 19-X-2009, coll. K. Attasopa & P. Phukphume (leg. NC and NW); 1♀, 2♂, Lomsak district, Bungkla subdistrict, 20-X-2009, coll. K. Attasopa & P. Phukphume (leg. NC and NW); 1♀, Lomsak district, Bungkla subdistrict, 21-X-2009, coll. K. Attasopa & P. Phukphume (leg. NC and NW). Phitsanulok Province: 1♀, Phuhinrongkla Nat. P., Lan hin pum, 16°59'49.8008"N, 101°00'40.6772"E, Alt. 1303 m, VI. 17. 2017., Aerial net, coll N. Warrit et al. (leg. NC and NW). Ratchaburi Province: 1♀, Suan Pheung district, 25-V-2012, coll. N. Warrit (leg. NC and NW). Samut Sakhon Province: 1♀, Banpaew district, 19-VIII-2014, coll. P. Tangtorwongsakul (leg. NC and NW). Suphan Buri Province: 1♂, 9-X-2012, coll. Veerawan (leg. NC and NW). Trang Province: 1♂, Na Yong district, 7°33'8.0892"N, 99°46'33.6072"E, Alt. 24 m, 11-VI-2015, coll. Warrit et al. (leg. NC and NW). Ubon Ratchathani Province: 1♂, Trakan Phuetphon district, Sarin lake view village, 03-VIII-2014, coll. N. Chatthanabun (leg. NC and NW).

Comments. There are some suspect specimens that show variation in both sexes of *M. umbripennis*. One female collected from Phitsanulok province (BSRU AA-4620) shows the following variations: lack of fulvous hairs on disc area of mesoscutum and lack of white hairs on T2–T5 (Fig. 27a–h). Males collected from Chiang Mai province (BSRU AA-3654, BSRU AA-3662) and Suphan Buri province (KKIC-02) have fulvous hairs on T2–T5 instead of white hairs (Fig. 29a–k).

Figures 29. *Megachile* (*Callomegachile*) *umbripennis* Smith, 1853 (BSRU AA-3654, BSRU AA-3662 and KKIC-02), male **a** dorsal view **b** lateral view **c** frontal view **d** clypeus and mandible **e** dorsal view of mesoscutum **f** T6 **g** ventral view of metasomal sterna showing scopa dorsal view of metasomal sterna **h** dorsal view of S8 **i** S5 **j** T7 **k** dorsal (left) and ventral (right) views of penis.

***Megachile* (*Callomegachile*) *chiangmaiensis* Chatthanabun & Warrit, sp. nov.**
http://zoobank.org/037E992C-1DB2-4BA4-B5EB-6684A3F4374F
Figs 30, 31

Diagnosis. The species superficially resembles *M. disjuncta* (Fabricius, 1781) in terms of its overall appearance and size: white tuft of hairs on scutellum, propodeum, and first few segments of metasomal terga; however, the prominent apical half-circular impression of clypeus with strong median carina (Fig. 31e) differentiates *M. chiangmaiensis* sp. nov. from the former. Clypeal impression smooth with dense dark hairs at apex. Such a clypeal impression was also present in another species of *Callomegachile*, *M. ramakrishnae* (Cockerell, 1919), a rare bee collected in Tamil Nadu, India, although the impression in *M. ramakrishnae* is more or less shallower and the pattern of the mesosoma and white hairs band on T2–T3 are absent. The apex of the labrum is strongly pointed medially with two lateral teeth (Fig. 31f).

Description. ***Female.*** Length. Total body length 12.57–13.64; wingspan 18.60–22.56; fore wing 9.66 Structure and color. Head black; paraocular area with dense black hairs; clypeus with prominent apical half-circular impression with strong median carina; clypeal impression smooth with dense dark hairs at apex; smooth area of subtriangular supraclypeal with sparse punctures; mandible stout and elongate with-

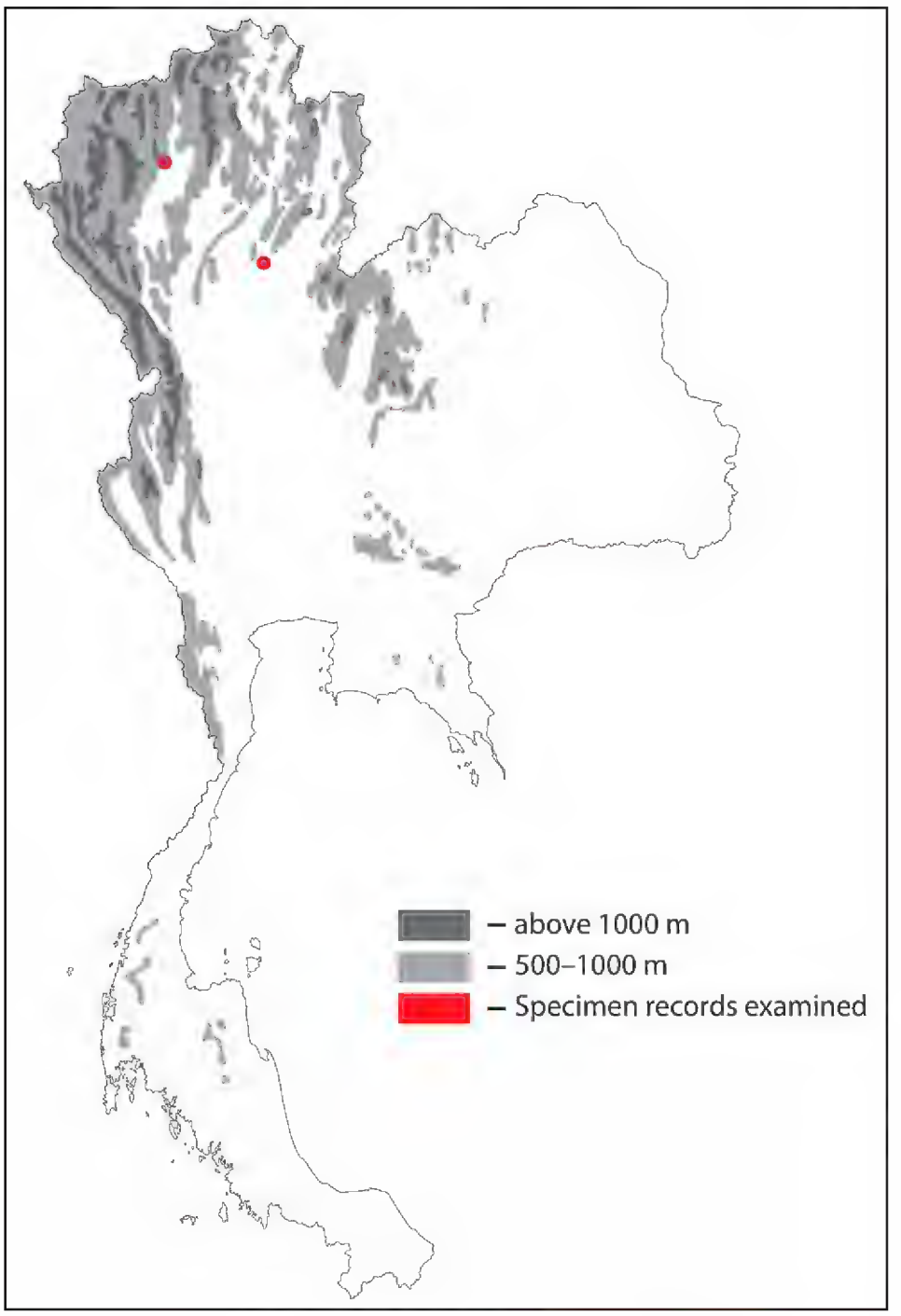


Figure 30. Thai distribution of *Megachile* (*Callomegachile*) *chiangmaiensis* new species.

out cutting edge, mandible with three apical teeth, outer surface minutely roughened with long brown hairs; surface of labrum minutely roughened, apex of labrum medially strongly pointed with two lateral teeth; gena with sparse punctures; sparse punctures on vertex with ID shorter than OD, ID/OD = 0.55 ± 0.06; antennae with ten flagella, first flagellomere wider than long and shorter than the second; body parallel-sided; mesoscutum and lower part of mesepisternum with coarsely striate puncture pattern; mesoscutellum and propodeum with tuft of white hairs; procoxa with small ridge, covered with sparse brown hairs; pro- and mesotibiae with two spines at apices; apex of metatibiae truncate; pro-, meso- and metatarsi with dense brown short hairs; hyaline wings with smoky color at apex and dark brown veins; T1 and pregradular area of T2 covered with tuft of white hairs; T2–T5 with dense punctures on margin and short black hairs on each side; T6 covered with short black hairs, apex round shape; scopa black.

Male. Unknown.

Distribution. Thailand. Chiang Mai and Uttaradit.

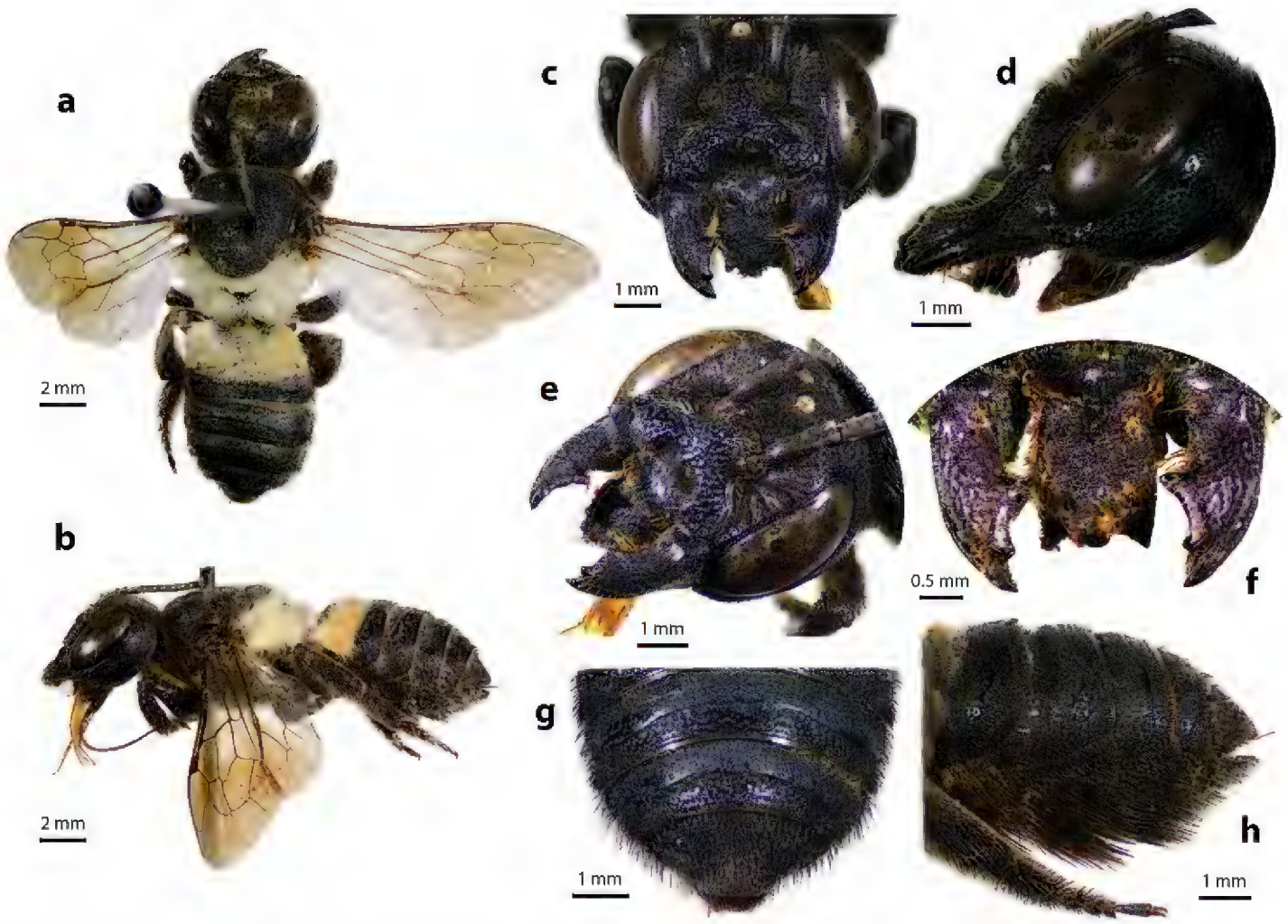


Figure 31. *Megachile* (*Callomegachile*) *chiangmaiensis* Chatthanabun and Warrit, sp. nov., holotype, female **a** dorsal view **b** lateral view **c** frontal view **d** lateral view of mandible **e** oblique view of clypeus **f** clypeus and mandible **g** T6 **h** lateral view of metasoma showing scopa.

Material examined. Female holotype. Thailand. "**เชียงใหม่**, 11 **ก.ย.** 56, **วิมลชัย** [Chiang Mai, 11 September 2013, coll. Vimolchai]" (KKIC-01); Female paratypes. Thailand. "Uttaradit, 8 April 1961, coll. unknown" (3♀, DNP-0002, DNP-0003, DNP-0004).

Etymology. The new species is named after the type locality.

Remarks. *Megachile chiangmaiensis* sp. nov. can be found in the same province as the morphologically similar congeneric species, *M. disjuncta*, although the latter are abundantly collected throughout Thailand. The biology of *M. chiangmaiensis* is unknown.

Megachile (*Carinula*) Michener, McGinley, & Danforth, 1994

Chalicodoma (*Carinella*) Pasteels, 1965: 447. Type species: *Megachile torrida* Smith, 1853, by original designation.

Megachile (*Carinula*) Michener, McGinley, & Danforth, 1994: 174, replacement for *Carinella* Pasteels, 1965. Type species: *Megachile torrida* Smith, 1853, autobasic.

Diagnosis. Body size median to small. Female mandible four to five teeth. Clypeus with median carina. Clypeal margin crenulate with five teeth. In males, coxal spine absent, front tarsi simple and carina of T6 extremely reduced.

Comments. *Carinula* is superficially similar to *Callomegachile*, especially striated punctures on mesoscutum and lower part of mesepisternum. Female of *Carinula* can be recognized by the presence of crenulate clypeal margin, whereas male can be recognized by reduced carina on T6.

Megachile (*Carinula*) *stulta* Bingham, 1897

Figs 32, 33

Megachile stulta Bingham, 1897: 476; Female syntype (NHMUK, examined) Sikkim, India.

Diagnosis. Female can be recognized by its medium to small body size (7.83–10.39 mm); rough clypeus with median carina, apical margin crenulate (Fig. 33b); mandibles four teeth with two stout apical teeth at apex and two small teeth basally; labrum rectangular (Fig. 33c); metasoma covered with ferruginous hairs (Fig. 33e); scopa ferruginous except white basal area (Fig. 33f).

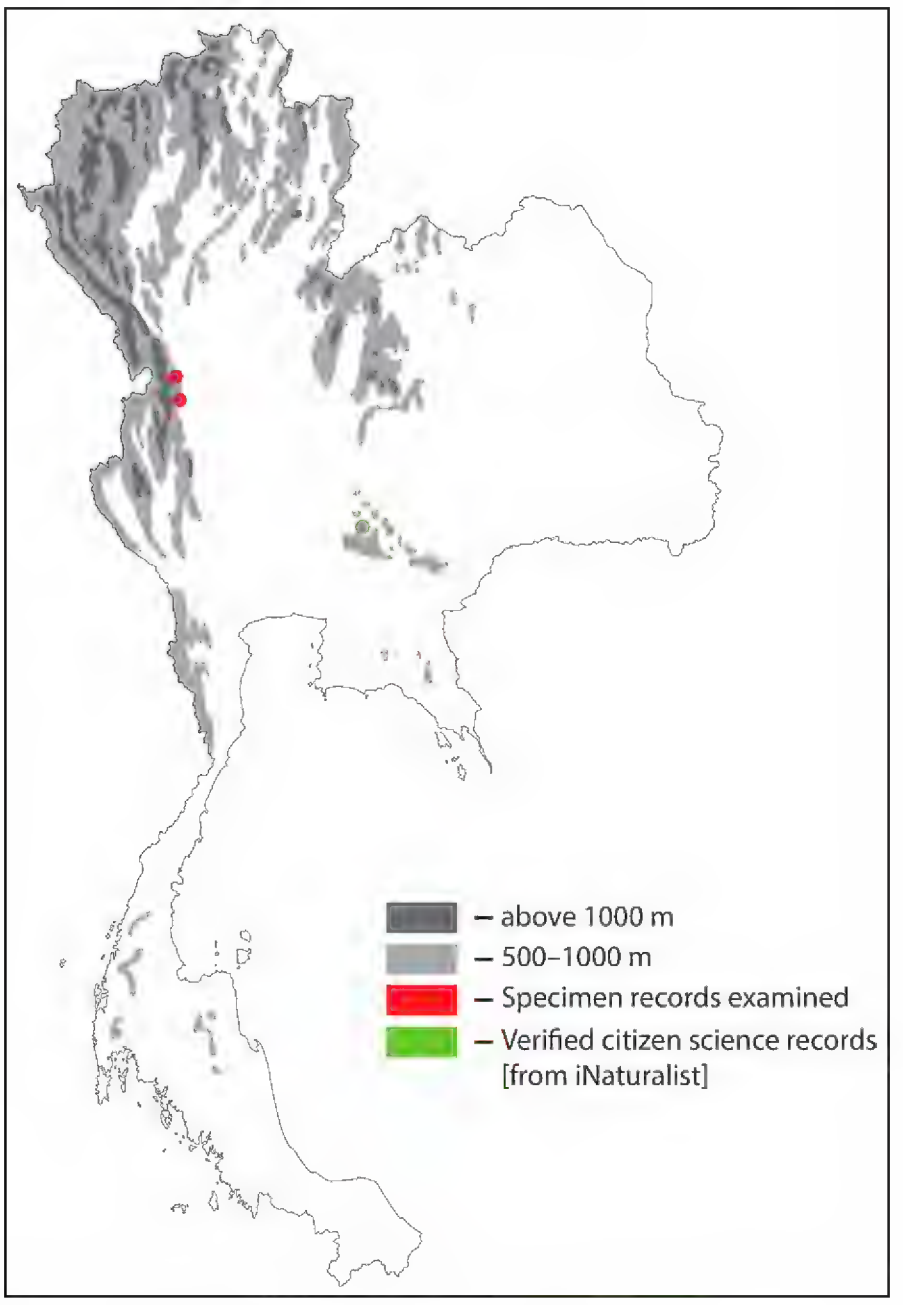


Figure 32. Thai distribution of *Megachile* (*Carinula*) *stulta*.

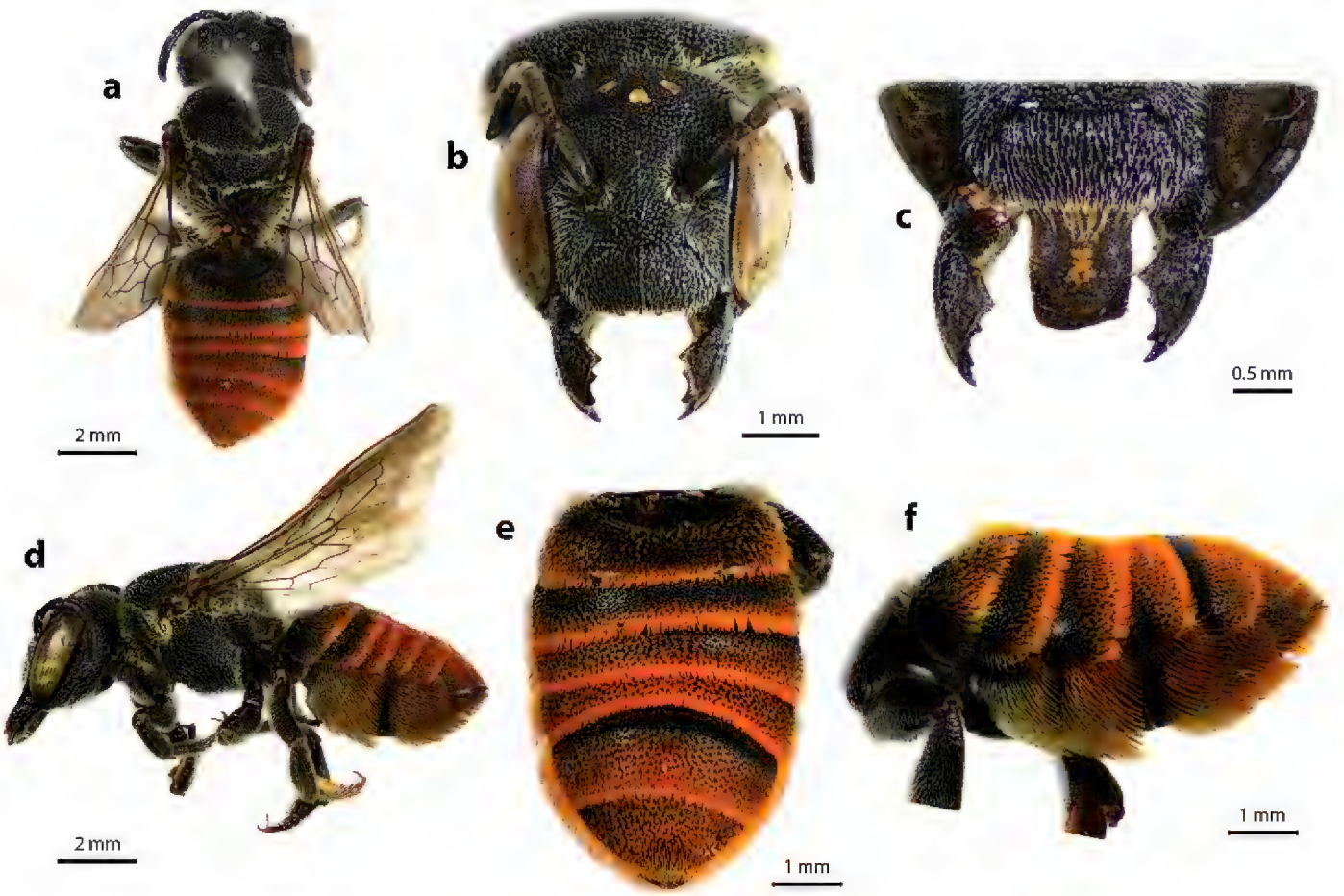


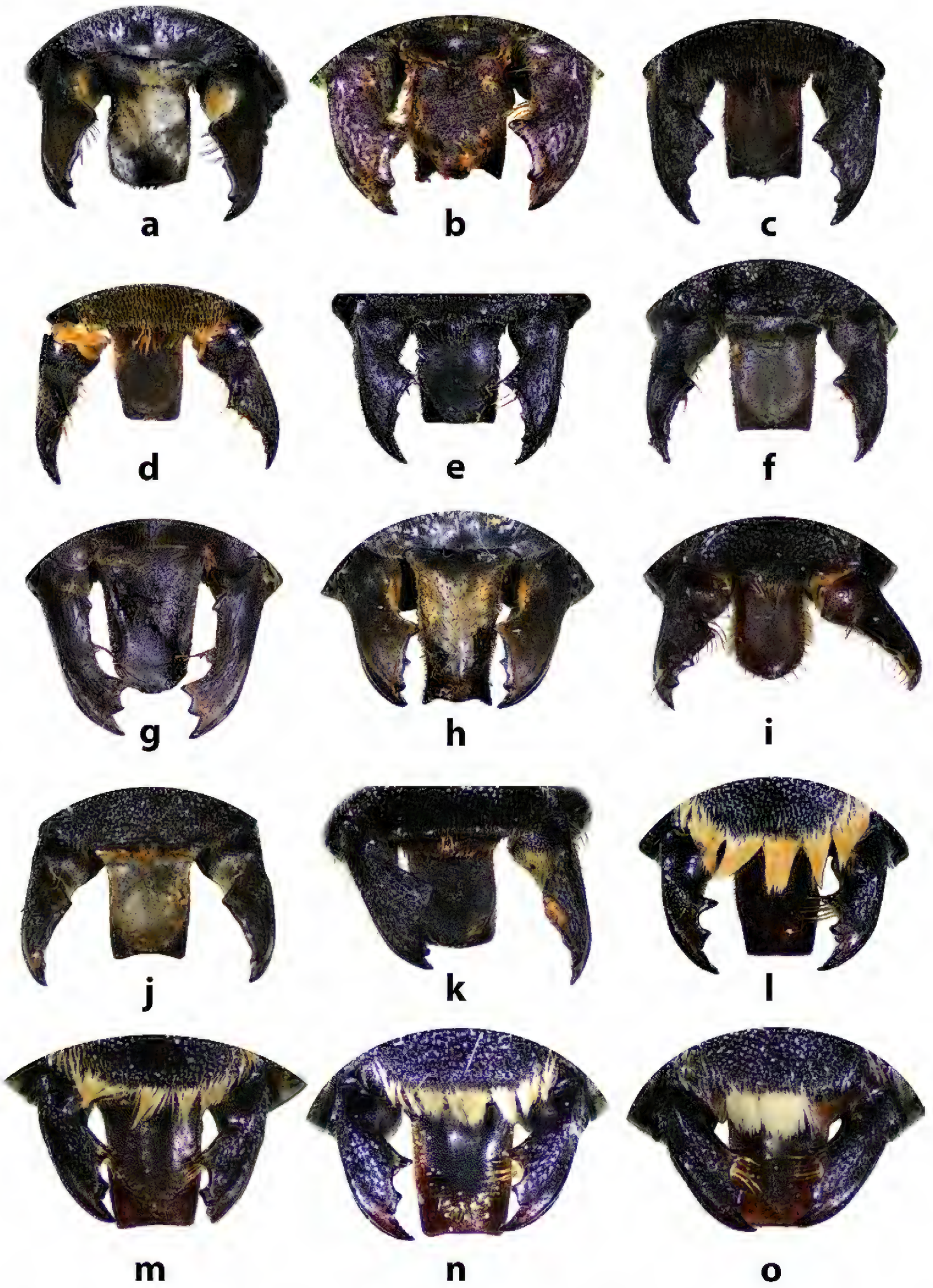
Figure 33. *Megachile* (*Carinula*) *stulta* Bingham, 1897, female **a** dorsal view **b** frontal view **c** frontal view of mandible and labrum **d** lateral view **e** dorsal view of metasoma **f** lateral view of metasoma and scopa.

Literature records. India. Karnataka, Sikkim (Ascher et al. 2016; Ascher and Pickering 2020); Indonesia. Sumatra (Bingham 1897; Ascher and Pickering 2020); Malaysia. Kuala Lumpur, Selangor (Ascher et al. 2016; Ascher and Pickering 2020); Myanmar. Tenasserim (Bingham 1897); Singapore. (Ascher et al. 2016). In addition, six females of this species was among numerous megachilids photographed together at Hin Tung, Mueang District, Nakhon Nayok Province (iNaturalist) (credit: scottyastro 2015; shuanda 2019).

Material examined. Female syntype. India. "Type; B.M. TYPE. 17.a.2161b; *Megachile stulta* Bingh, female, Type.; SIKKIM, Rungjit Valley, 1000 ft., 4.94, BINGHAM COLL., Col. C. T. Bingham 96–30; NHMUK 013380269"; Thailand. Kamphaeng Phet Province: 1♀, Khlong Lan, Khlong Lan waterfall, 08-IV-2014, coll. C. Wimolsuthikul & S. Wongvilas (leg. NC and NW); 36♀, Pang Sila Thong district, Mae Wong National Park, Kang Pha Khoi Nang, 07-VIII-2015, coll. N. Warrit et al. (leg. NC and NW).

Notes on *Callomegachile* from Thailand

Two of the most common species of *Megachile* (*Callomegachile*) sensu lato found in Thailand are *M.* (*Callomegachile*) *disjuncta* and *M.* (*Callomegachile*) *umbripennis*, and these are also the most common species of this group in Singapore (Ascher et al. 2016). *Megachile* (*Callomegachile*) *disjuncta* is usually collected from *Crotalaria juncea* L. across most of Thailand.



Figures 34. Distal edges of labrums and mandibles of some Thai *Callomegachile* (**a–k** females, **l–o** males) **a** *M.* (*Callomegachile*) *atratiformis* **b** *M.* (*Callomegachile*) *chiangmaiensis* sp. nov. **c, l** *M.* (*Callomegachile*) *disjuncta* **d, m** *M.* (*Callomegachile*) *faceta* **e** *M.* (*Callomegachile*) *fulvipennis* **f** *M.* (*Callomegachile*) *impressa* **g** *M.* (*Callomegachile*) *monticola* **h** *M.* (*Callomegachile*) *odontophora* **i** *M.* (*Callomegachile*) *parornata* **j, n** *M.* (*Callomegachile*) *umbripennis* **k** *M.* (*Callomegachile*) *umbripennis* (BSRU AA-4620) **o** *M.* (*Callomegachile*) *umbripennis* (BSRU AA-3654, BSRU AA-3662 and KKIC-02).

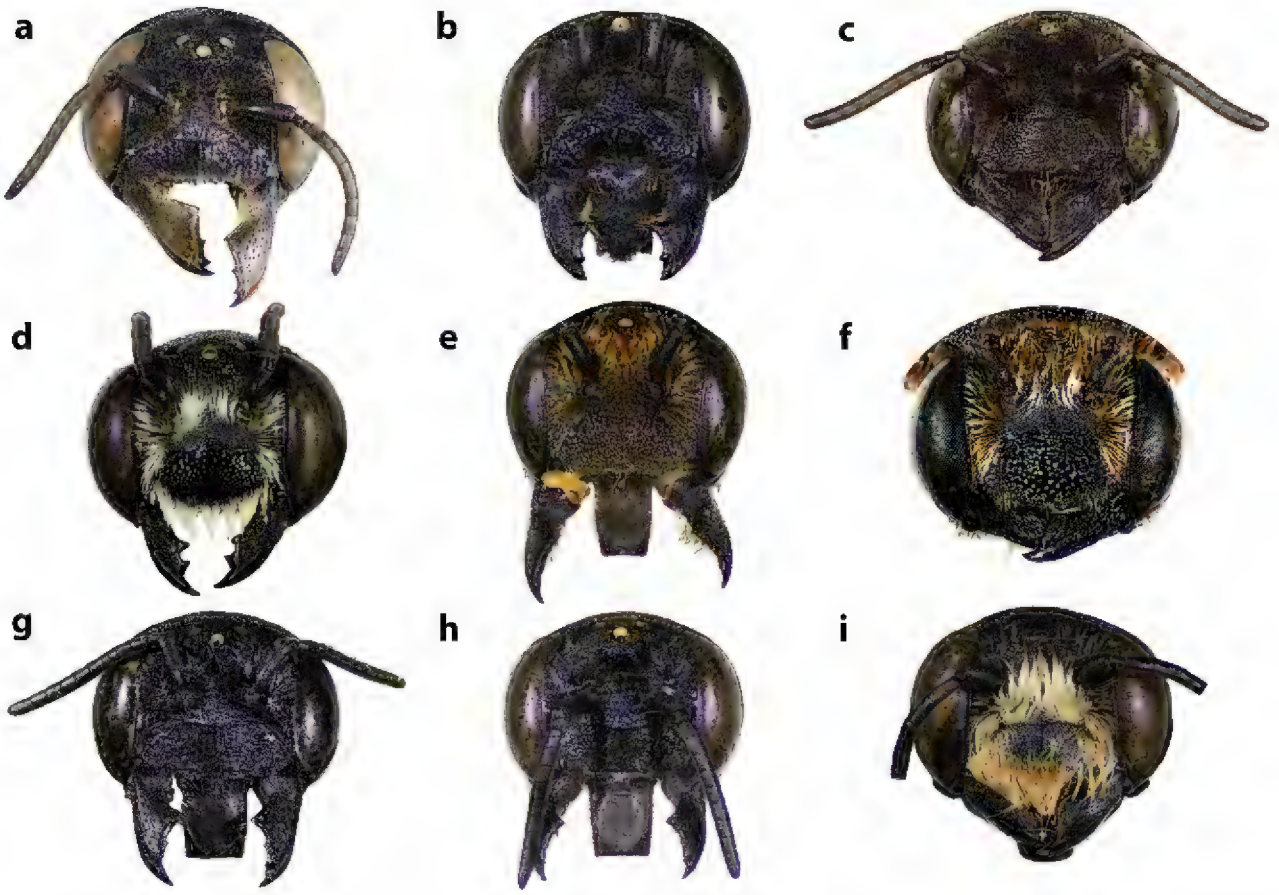


Figure 35. Frontal view of some Thai *Callomegachile* (**a–c, e, g, h** females, **d, f, i** males) **a** *M.* (*Callomegachile*) *atratiformis* **b** *M.* (*Callomegachile*) *chiangmaiensis* sp. nov. **c, d** *M.* (*Callomegachile*) *disjuncta* **e, f** *M.* (*Callomegachile*) *faceta* **g** *M.* (*Callomegachile*) *fulvipennis* **h** *M.* (*Callomegachile*) *impressa* **i** *M.* (*Callomegachile*) *memecylonae*.

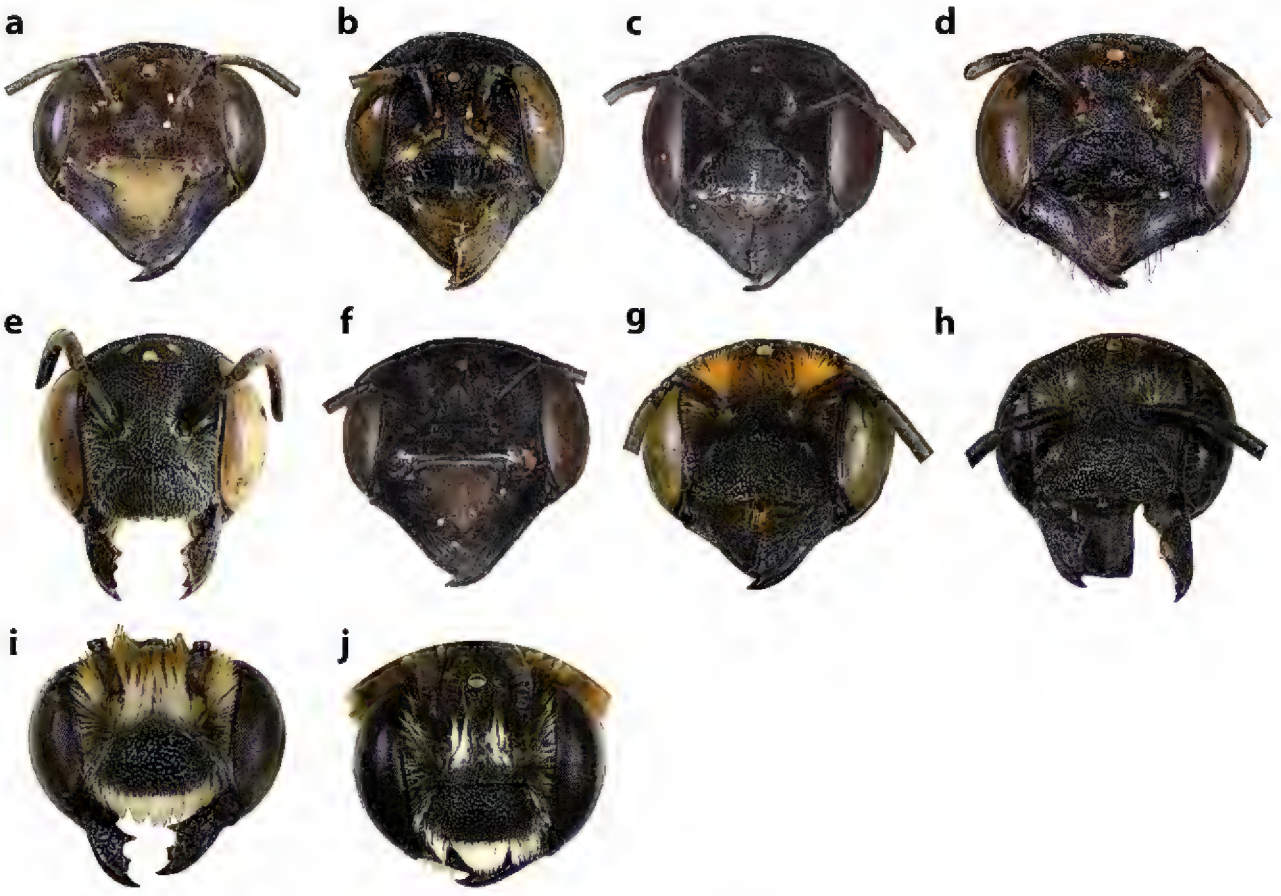


Figure 36. Frontal view of some Thai *Callomegachile* (**a–h** females, **i, j** males) **a** *M.* (*Callomegachile*) *monticola* **b** *M.* (*Callomegachile*) *odontophora* **c** *M.* (*Callomegachile*) *ornata* **d** *M.* (*Callomegachile*) *parornata* **e** *M.* (*Carinula*) *stulta* **f** *M.* (*Callomegachile*) *tuberculata* **g, i** *M.* (*Callomegachile*) *umbripennis* **h** *M.* (*Callomegachile*) *umbripennis* (BSRU AA-4620) **j** *M.* (*Callomegachile*) *umbripennis* (BSRU AA-3654, BSRU AA-3662 and KKIC-02).

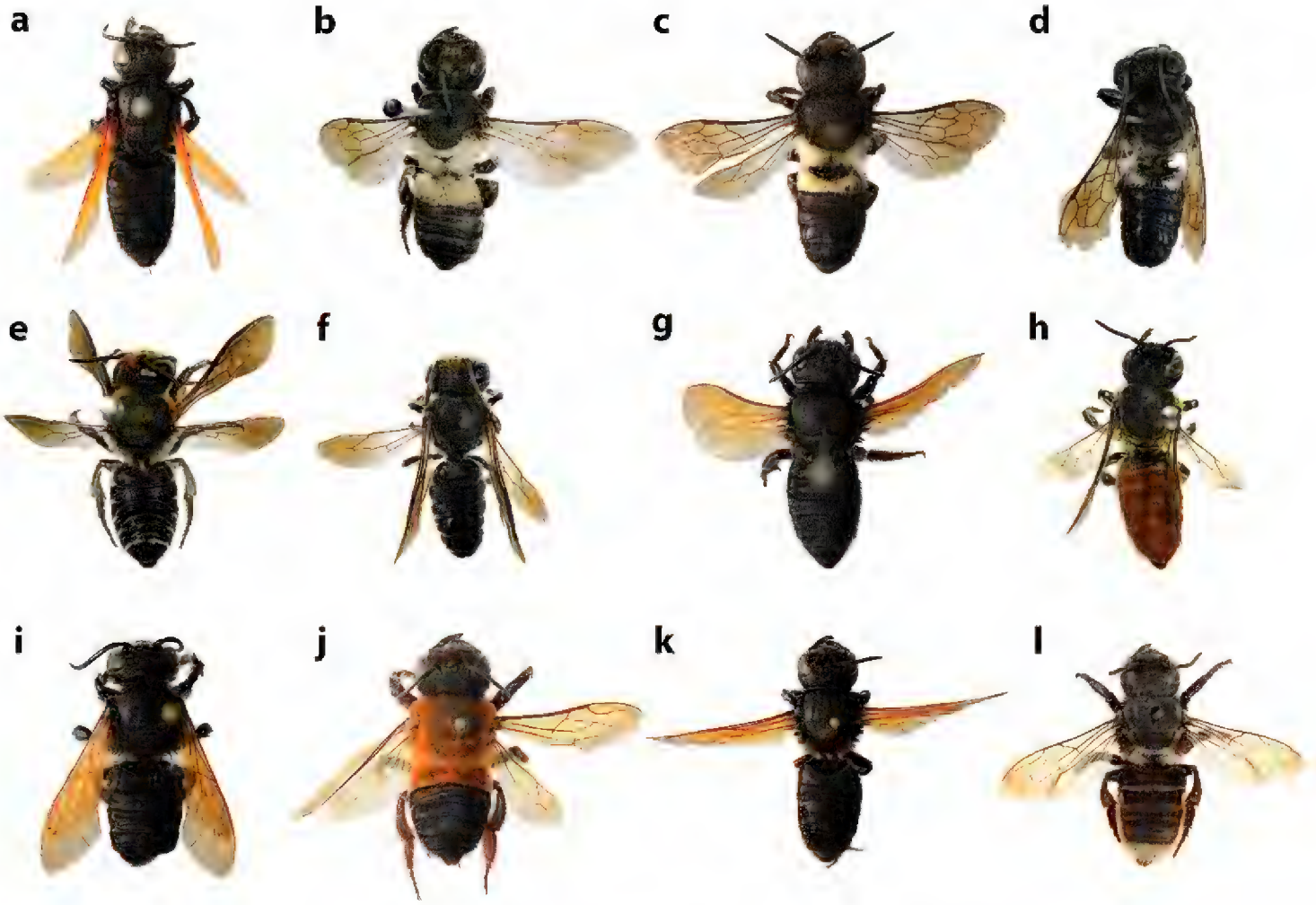


Figure 37. Dorsal view of some Thai *Callomegachile* (**a–c, e, g, h, j–l** females, **d, f, i** males) **a** *M.* (*Callomegachile*) *atratiformis* **b** *M.* (*Callomegachile*) *chiangmaiensis* sp. nov. **c, d** *M.* (*Callomegachile*) *disjuncta* **e, f** *M.* (*Callomegachile*) *faceta* **g** *M.* (*Callomegachile*) *fulvipennis* **h** *M.* (*Callomegachile*) *impressa* **i** *M.* (*Callomegachile*) *memecylonae* **j** *M.* (*Callomegachile*) *monticola* **k** *M.* (*Callomegachile*) *odontophora* **l** *M.* (*Callomegachile*) *ornata*.

Figure 38. Dorsal view of some Thai *Callomegachile* (**a–e** females, **f, g** male) **a** *M.* (*Callomegachile*) *parornata* **b** *M.* (*Carinula*) *stulta* **c** *M.* (*Callomegachile*) *tuberculata* **d, f** *M.* (*Callomegachile*) *umbripennis* **e** *M.* (*Callomegachile*) *umbripennis* (BSRU AA-4620) **g** *M.* (*Callomegachile*) *umbripennis* (BSRU AA-3654, BSRU AA-3662 and KKIC-02).

This is the first study to emphasize the importance of labral shape (Fig. 34a–o) for the identification in female *Callomegachile* species. In Thailand, *M.* (*Callomegachile*) *disjuncta* is the only species that has two prominent lateral teeth on distal edge of labrum (Fig. 34c), whereas in *M.* (*Callomegachile*) *fulvipennis*, *M.* (*Callomegachile*) *impressa* and *M.* (*Callomegachile*) *faceta* the lateral teeth are less prominent (Fig. 34e, f, d). *Megachile* (*Callomegachile*) *umbripennis* in Thailand has smooth and slightly concave distal edge of labrum (Fig. 34j). *Megachile* (*Callomegachile*) *parornata* has convex distal edge of labrum and *M.* (*Callomegachile*) *chiangmaiensis* sp. nov. has a distinct distal edge: medially convex with large lateral teeth (Fig. 34b). Further investigation into the applicability of the labral distal edge as diagnostic character in other *Callomegachile* species should be carried out.

Key to female species of subgenera *Callomegachile* and *Carinula* in Thailand

1 Pronotum, mesoscutum, and scutellum covered with white and/or black hairs **2**

– At least pronotum or mesoscutum and scutellum covered and/or fringed with fulvous hairs **12**

2 Most metasomal terga covered with red brick hairs or covered with black hairs with fringe of red brick hairs on lateral areas of T2–T5 (Figs 20a, 22d); scopa brick-red **3**

– Most metasomal terga covered with black hairs (sometimes T1 with band of white hairs (Figs 2a, 4a); scopa black **6**

3 Second spine of pro- and mesotibiae bifurcate (Figs 20c, 22f) **4**

– Second spine of pro- and mesotibiae not bifurcate **5**

4 T1–T4 covered with black hairs, T2 with small patch of brick-red hairs laterally; T5–T6 covered with pale light yellow hairs (Fig. 20e) ..... ***M. ornata***

– T1 covered with black hairs; T2–T5 cover with brick-red hairs; T6 covered with light yellow hairs (Fig. 22g, h) ..... ***M. parornata***

5 Clypeal margin with two small tubercles; mandible five teeth with two stout apical teeth and three small teeth basally ..... ***M. impressa***

– Clypeal margin crenulate with median carina (Fig. 33b, c); mandible four teeth ..... ***M. stulta***

6 T1 and propodeum covered with white hairs 7

– T1 and propodeum covered with black hairs **8**

7 Clypeus with prominent apical impression and strong median carina (Fig. 31e); mandible with three stout teeth at apex; labrum oblong, apical margin medially strongly pointed with two lateral teeth (Fig. 31f) ..... ***M. chiangmaiensis* sp. nov.**

– Clypeus without apical impression, apical margin smooth with two tubercles (Fig. 4d); mandible five teeth with two stout apical teeth at apex and three small teeth basally; labrum rectangle, apical margin truncate with two lateral teeth (Fig. 4e) ..... ***M. disjuncta***

8 Base of clypeus with large protruding tubercle (Fig. 16b); mandible three teeth with small tubercle at base ..... ***M. tuberculata***

– Base of clypeus without large protruding tubercle; mandible four to five teeth without small tubercle at base **9**

9 Mandible with five teeth with two stout apical teeth at apex and three small teeth basally; medium size (15–16 mm) ..... ***M. fulvipennis***

– Mandible with four teeth; large size (20–23 mm) **10**

10 Apical margin of clypeus with small median tubercle (Fig. 18e); labrum oblong, apical pointed with two lateral teeth (Fig. 18d) ..... ***M. odontophorum***

– Apical margin of clypeus without median tubercle; labrum rectangle, apical margin truncate without teeth **11**

11 Mesoscutum with strong transverse wrinkle pattern on disc, posteriorly with irregular punctures ..... ***M. memecylonae***

– Mesoscutum with weak transverse wrinkle pattern on disc, posteriorly with weakly transverse wrinkle pattern-like disc ..... ***M. atratiformis***

12 Fulvous or black tergal hair bands; base of clypeus with large protruding tubercle (Fig. 16b); mandible three teeth with small tubercles at base (Fig. 16c); scopa black; large size (20–26 mm) ..... ***M. monticola***

– White tergal hair bands, sometimes interrupted at median, base of clypeus without large protruding tubercle; mandible five teeth with two stout apical teeth at apex and three small teeth basally without tubercle at base; scopa white with black at apex; median size (10–13 mm) **13**

13 Vertex with median carina (Fig. 7e); only pronotum covered with fulvous hairs; propodeal triangle with tuft white hairs ..... ***M. faceta***

– Vertex without median carina; pronotum, mesoscutum, and scutellum covered with dense fulvous hairs throughout; propodeal triangle with dense fulvous hairs ..... ***M. umbripennis***

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References

Alfken JD (1898) *Megachile schauinslandi* sp. nov. Eine neue *Megachile*-Art aus Honolulu. Entomologische Nachrichten 1: 340–341.

Ascher JS, Risch S, Soh ZWW, Lee JXQ, Soh EJY (2016) *Megachile* leaf-cutter and resin bees of Singapore (Hymenoptera: Apoidea: Megachilidae). Raffles Bulletin of Zoology Supplement 32: 33–55.

Ascher JS, Pickering J (2020) Bee Species Guide (Hymenoptera: Apoidea: Anthophila). http://www.discoverlife.org/mp/20q?guide=Apoidea_species [Draft 5, last accessed 15 July 2019]

Baker DB, Engel MS (2006) A new subgenus of *Megachile* from Borneo with arolia. American Museum Novitates 3505: 1–12. https://doi.org/10.1206/0003-0082(2006)505[0001:ANSOMF]2.0.CO;2

Bingham CT (1890) On new and little known Hymenoptera from India, Burma and Ceylon. The Journal of the Bombay Natural History Society 5: 233–252.

Bingham CT (1896) New and little known species of Indo-Malayan Hymenoptera, with a key to genera of Indian Pompilidae, and a note on *Sphex flava* of Fabricius, and allied species. The Journal of the Bombay Natural History Society 10: 195–216.

Bingham CT (1897) The Fauna of British India Including Ceylon and Burma, Hymenoptera (Vol. I). Wasps and Bees. Taylor & Francis, London, 577 pp. https://doi.org/10.5962/bhl.title.100738

Cameron P (1897) Hymenoptera Orientalia, or Contributions to a knowledge the Hymenoptera of the Oriental Zoological Region Part V. Memoirs and proceeding of the Manchester & Philosophical Society 41: 1–144.

Cameron P (1907) Hymenoptera. The Transactions of the Linnean Society of London 12(2): 69–86. https://doi.org/10.1111/j.1096-3642.1907.tb00510.x

Cockerell TDA (1911) Descriptions and Records of Bees – XXXV. The Annals and Magazine of Natural History, including Zoology, Botany, and Geology 7(8): 310–319. https://doi.org/10.1080/00222931108692943

Cockerell TDA (1912) Hymenoptera, Apoidea. The Transactions of the Linnean Society of London 15(2): 29–41. https://doi.org/10.1111/j.1096-3642.1912.tb00087.x

Cockerell TDA (1919) Descriptions and Records of Bees – LXXXIV. Annals and Magazine of Natural History 3: 191–198. https://doi.org/10.1080/00222931908673809

Cockerell TDA (1927a) Some bees, principally from Formosa and China. American Museum Novitates 274: 1–16.

Cockerell TDA (1927b) Bees collected by Dr. H. M. Smith on Turtle Island (Koh Tao) Gulf of Siam. Proceedings of the Entomological Society of Washington 29: 160–162.

Cockerell TDA (1931) Bees obtained by Professor Claude R. Kellogg in the Foochow district, China, with new records of Philippine Bombidae. American Museum Novitates 480: 1–7.

Davies OK, Groom SVC, Ngo HT, Stevens MI, Schwarz MP (2013) Diversity and origins of Fijian leaf-cutter bees (Megachilidae). Pacific Science 67(4): 561–570. https://doi.org/10.2984/67.4.7

Dover C (1921) The wasps and bees of Barkuda island. Journal of Indian Zoology 22: 381–391.

Dover C (1929) Wasps and Bees in the Raffles Museum, Singapore. Bulletin of the Raffles Museum, Singapore 2: 43–70.

Engel MS (2001) A monograph of the Baltic amber bees and evolution of the Apoidea (Hymenoptera). Bulletin of the American Museum of Natural History 259: 1–192. https://doi.org/10.1206/0003-0090(2001)259%3C0001:AMOTBA%3E2.0.CO;2

Engel MS, Gonzalez VH (2011) *Alocanthedon*, a new subgenus of *Chalicodoma* from Southeast Asia (Hymenoptera, Megachilidae). ZooKeys 101: 51–80. https://doi.org/10.3897/zookeys.101.1182

Fabricius JC (1781) Species Insectorvm Exhibentes Eorvn Differentias Specificas, Synonyma Avctorvm, Loca Natalia, Metamorphosin Adiectis Observationibvs, Descriptionibvs. Hamburg und Kilon, Bohn, 552 pp. https://doi.org/10.5962/bhl.title.36509

Fabricius JC (1804) Systema Piezatorum Secundum Ordines, Genera, Species Adiectis Synonymis, Locis, Observationibus, Descriptionibus. Brunsvigae, Reichard, 439 pp. https://doi.org/10.5962/bhl.title.10490

Flectcher B (1920) Annotated list of Indian Crop-pests. Report of the Proceedings of the Third Entomological Meeting 1: 33–314.

Friese H (1903) Neue Megachile-Arten des Sunda-Archipels. Zeitschrift für systematische Hymenopterologie und Dipterologie 3: 349–359.

Friese H (1911) Apidae I. Megachilinae. Friedländer, Berlin, 440 pp.

Gonzalez VH (2008) Phylogeny and Classification of the Bee Tribe Megachilini (Hymenoptera: Apoidea, Megachilidae), with Emphasis on the Genus Megachile. Ph.D. Dissertation, University of Kansas, Lawrence, Kansas, 274 pp. [Available electronically via the University of Kansas libraries]

Gonzalez VH, Engel MS (2012) African and southeast asian *Chalicodoma* (Hymenoptera: Megachilidae): new subgenus, new species, and notes on the composition of *Pseudomegachile* and *Largella*. Annales Zoologici 62: 599–617. https://doi.org/10.3161/000345412X659669

Gonzalez VH, Gustafson GT, Engel MS (2019) Morphological phylogeny of Megachilini and the evolution of leaf-cutter behavior in bees (Hymenoptera: Megachilidae). Journal of Melittology 85: 1–123. https://doi.org/10.17161/jom.v0i85.11541

Gribodo G (1884) Sopra alcuni imenotteri raccolti a minhla nel regno di birmania. Annali del museo civico di storia naturale di Genova 1: 350–368.

iNaturalist (2020) iNaturalist [online]. https://www.inaturalist.org [last accessed 07 July 2020]

Jurine PL (1807) Nouvelle Méthode de Classer les Hyménoptères et les Diptères. Paschoud, Geneva, 320 pp. https://doi.org/10.5962/bhl.title.60886

Kirby WF (1894) A Visit to Damma Island, East Indian Archipelago. The Annals and Magazine of Natural History, including Zoology, Botany, and Geology 14(6): 107–110.

Krombein KV (1950) The Aculeate Hymenoptera of Micronesia II. Colletidae, Halictidae, Megachilidae, and Apidae. Proceedings, Hawaiian Entomological Society 14: 101–142.

Kuhlmann M (2006) Fauna and biogeography of the bees and wasps of the Cook Islands (Hymenoptera). Journal of Hymenoptera Research 15(1): 26–37.

Latreille PA (1802) Histoire Naturelle des Fourmis: et Recueil de Mémoires et D'observations sur les Abeilles, les Araignées, les Faucheurs, et Autres Insects. Crapelet, Paris, 445 pp. https://doi.org/10.5962/bhl.title.11138

Lepeletier de Saint-Fargeau ALM (1841) Histoire Naturelle des Insectes – Hyménoptères [Vol. 2]. Roret, Paris, 680 pp.

Litman JR, Danforth BN, Eardley CD, Praz CJ (2011) Why do leafcutter bees cut leaves? New insights into the early evolution on bees. Proceedings of the Royal Society 278: 3593–3600. https://doi.org/10.1098/rspb.2011.0365

Meade-Waldo G (1912) Notes on the Apidae (Hymenoptera) in the collection of the British Museum, with descriptions of new species. The Annals and Magazine of Natural History, including Zoology, Botany, and Geology 10: 461–478. https://doi.org/10.1080/00222931208693261

Meade-Waldo G (1914) Note on the Hymenoptera in the collection of the British Museum, with descriptions of new species. Annals and Magazine of Natural History 14: 450–464. https://doi.org/10.1080/00222931408693601

Michener CD, McGinley RJ, Danforth BN (1994) The Bee Genera of North and Central America. Smithsonian Institution Press, Washington, 209 pp.

Michener CD (1962) Observations on the classification of the bees commonly placed in the genus *Megachile* (Hymenoptera: Apoidea). Journal of the New York Entomological Society 70(1): 17–29.

Michener CD (1965) A classification of the bees of the Australian and South Pacific regions. Bulletin of the American Museum of Natural History 130: 1–362.

Michener CD, Fraser A (1978) A comparative anatomical study of mandibular structure in bees. University of Kansas Science Bulletin 51(14): 463–482. https://doi.org/10.5962/bhl.part.17245

Michener CD (2000) The Bees of the World (1st edn.). Johns Hopkins University Press, Baltimore, 913 pp.

Michener CD (2007) The Bees of the World (2nd edn.). Johns Hopkins University Press, Baltimore, 953 pp.

Mocsáry A (1892) In expeditione comitis belae szechenyi in China et Tibet a Dom. G. Kreitner et l. L. Lóczy anno 1879 collexta. Természetrajzi füzetek 16: 126–131.

Pasteels JJ (1965) Révision des Megachilidae (Hymenoptera Apoidea) de l'Afrique Noire. I. Les genres *Creightoniella* [sic], *Chalicodoma* et *Megachile* (s. str.). Koninklijk Museum voor Midden-Afrika, Tervuren, België, Annalen, Reeks In-8°, Zoologische Wetenschappen, 137: 1–579.

Pauly A, Brooks RW, Nilsson LA, Apesenko Y, Eardley CD, Terzo M, Griswold T, Schwarz M, Patiny S, Munzinger J, Barbier Y (2001) Hymenoptera Apoidea de Madagascar et des iles Voisnes. Annales Sciences Zoologiques, Musée Royal de L'Afrique Centrale, Tervuren, 390 pp.

Perkins RCL (1899) Hymenoptera Aculeata. In: Sharp D (Ed.) Fauna Hawaiiensis or the Zoology of the Sandwich (Hawaiian) Isles. Cambridge University Press, 115 pp.

Radoszkowski O (1882) Opisanie nowych gatunków błonkoskrzydłych (Hymenoptera) [Description of new species of Hymenoptera] Wiadomości z Nauk Przyrodzonych (Warszawa) [Proceedings of the Warsaw Society of Naturalists, Bulletin of Biology] 2: 72–81.

Saussure H de (1890) Histoire Naturelle des Hyménoptères, In: Grandidier A (Ed.) Histoire Physique, Naturelle et Politique de Madagascar. Imprimerie Nationale, Paris, 590 pp. https://doi.org/10.5962/bhl.title.9201

Schulthess-Rechberg A von (1935) Hymenoptera aus den Sundainseln und Nordaustralien (mit Ausschluss der Blattwespen, Schlupfwespen und Ameisen). Revue suisse de zoologie annales de la société zoologique suisse et du muséum d'histoire naturelle de Genève 42: 293–323. https://doi.org/10.5962/bhl.part.117934

Smith F (1853) Catalogue of Hymenopterous insects in the collection of the British Museum. Taylor and Francis, London, 197 pp.

Smith F (1858) Catalogue of the Hymenopterous Insects collected at Sarawak, Borneo; Mount Ophir, Malacca; and at Singapore, by A. R. Wallace. Journal of the proceeding of the Linnean Society 2: 42–129. https://doi.org/10.1111/j.1096-3642.1857.tb01759.x

Smith F (1873) Descriptions of Aculeate Hymenoptera of Japan, collected by Mr. George Lewis at Nagasaki and Hiogo. The transactions of the Linnean Society of London: 181–206. https://doi.org/10.1111/j.1365-2311.1873.tb00641.x

Smith F (1879) Descriptions of New Species of Hymenoptera in the Collection of the British Museum. Taylor and Francis, London, 240 pp.

Soh ZWW, Ascher JS, Chua JLE (2017) Giant resin bee, *Megachile tuberculata*, in an urban community garden. Singapore Biodiversity Records 2017: 174–175.

Soh EJY, Soh ZWW, Chui SX, Ascher JS (2016) The bee tribe Anthidiini in Singapore (Anthophila: Megachilidae: Anthidiini) with notes on the regional fauna. Nature in Singapore 9: 49–62.

Strand E (1913) H. Sauter's Formosa-Ausbeute, Apidae I. Supplementa Entomologica No. 2: 23–67. https://doi.org/10.5962/bhl.part.14989

Tadauchi O, Tasen W (2009) Bees of natural forests, teak plantations and agricultural fields in Thailand. Esakia 49: 7–13.

Trunz V, Packer L, Vieu J, Arrigo N, Praz CJ (2016) Comprehensive phylogeny, biogeography and new classification of the diverse bee tribe Megachilini: Can we use DNA barcodes in phylogenies of large genera? Molecular Phylogenetics and Evolution 103: 245–259. https://doi.org/10.1016/j.ympev.2016.07.004

Wu YR (2005) A study on the genus *Megachile* Latreille from China with descriptions of fourteen species (Apoidea, Megachilidae). Acta Zootaxonomica Sinica 30(1): 155–165.